Tisbury MA Impervious Cover Disconnection (ICD) Project: An Integrated Stormwater Management Approach for Promoting Urban Community Sustainability and Resilience

A technical direct assistance project funded by the U.S. EPA Southeast New England Program (SNEP)

Task 4H. Quantifying Benefits for Municipal Long-Term GI SCM Implementation Strategies

Prepared for:

U.S. EPA Region 1

In Cooperation With:

Town of Tisbury, MA
Tisbury Waterways
Martha's Vineyard Commission
Massachusetts Department of Transportation

Prepared by:

Paradigm Environmental
University of New Hampshire Stormwater Center
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To:	Ray Cody, Mark Voorhees (US EPA Region 1)
From:	Khalid Alvi, David Rosa, Ryan Murphy (Paradigm Environmental)
CC:	Project Technical Team
Date:	2/25/2020
Re:	Quantifying benefits for municipal long-term GI SCM implementation strategies (Task 4H)

1 EXECUTIVE SUMMARY

This memorandum presents the technical approach for the application of Opti-Tool (U.S. EPA, 2016) to the evaluation of opportunities to address stormwater quantity and quality in Tisbury, MA. The Planning Level Analysis functionality in Opti-Tool was used to compare the cost-effectiveness of various Green Infrastructure (**GI**) and Stormwater Control Measures (**SCM**) design scenarios. The assessment includes a town-wide assessment and further describes opportunities and their associated costs and benefits within the town's nine zoning districts. This study expands upon a previously study (U.S. EPA, 2020) that focused on two outfalls, #2 and #7, in Tisbury. Together, the studies leverage both the Planning Level and Implementation Level Analyses options of Opti-Tool. The outlet study used the Implementation Level Analysis which allows users to apply the SUSTAIN optimization engine to estimate SCM performance and obtain optimization results to provide cost-effective SCM sizing strategies. The town-wide assessment presented in this memorandum relied on the Planning Level Analysis option in Opti-Tool. The planning level analysis provides a watershed-based overview of stormwater management opportunities for decision-makers to consider. The Planning Level Analysis used Excel Solver to find optimal solutions using existing SCM performance curves. Unlike the Implementation Level analysis, which produced cost effectiveness curves based on hundreds of thousands of possible SCM type and size combinations, the Planning Level Analysis assessed cost effectiveness over incremental SCM sizes. The Planning Level Analysis in this memorandum assumes that for each size increment (i.e. 0.1, 0.2 inches, etc), all SCMs in the watershed are built to that size.

Cost-effectiveness curves were generated town-wide and for each zoning district. The curves assess the costs and benefits, in terms of stormwater volume and TN load reduction, which can be expected over a range of GI-SCM sizes. At a planning level, the results demonstrate that if infiltration-based GI-SCM opportunities were designed to capture 0.4 inches of runoff from impervious surfaces, the result would be a 78% reduction in annual storm flow volume and an 81% in annual TN loading. An additional co-benefit of this level of control is to reduce annual indicator bacteria load in runoff by an estimated 66.5% - 80% assuming a GI-SCM infiltration rate of 1.02 in/hr. Approximately 78% of the runoff discharge events from treated IC areas per year would also be eliminated. This benefit could immediately lower impacts to recreational uses in local surface waters. The estimated cost to achieve these reductions was $13.54 million for the town's entire area of 6.37 square miles (4,079 acres).

The ability of long-term GI SCM strategies to achieve objectives beyond flood mitigation and nutrient load reductions, including urban community farming and affordable foods, urban aesthetics and safety, green jobs, and smart growth land use planning was also assessed. There is substantial evidence that suggests GI and SCM can be an integral part of holistic strategies that aim to make urban areas more sustainable and resilient while also enhancing the aesthetic quality of developed areas.

Recommendations: The data presented in this and previous memorandums provides strong support for the town of Tisbury to begin pursuing the implementation of GI SCM opportunities on both public and private lands. For Tisbury to successfully achieve long-term solutions to their stormwater issues, the following should be a top priority:

1) Adopt bylaws for new and redevelopment that aim to reduce directly connected impervious cover.
2) Adopt generic GI SCM design templates that can be easily incorporated into municipal infrastructure projects and urban renewal.

2 TECHNICAL APPROACH - PLANNING LEVEL ANALYSIS

The purpose of the Planning Level Analysis within Opti-Tool is to quickly evaluate multiple design scenarios with minimum data requirements and compare them without running a continuous SCM simulation in the more detailed Implementation Level Analysis mode of Opti-Tool. Two management goals we evaluated, the goal of reducing TN loading and the goal of reducing stormwater volume. For these two management goals, eight design scenarios were evaluated. The design scenarios represented incremental SCMs design sizes to capture between 0.1 and 2 inches of runoff from the contributing impervious cover. A design between 0.31 and 0.35 was previously identified as optimal sizes for TN and volume reduction for outfalls #2 and #7 (U.S. EPA, 2020). Six practices from a range of potential stormwater management methods were evaluated (Table 1). The six practices were two infiltration techniques, basins and trenches, on soil groups A, B, and C. Infiltration trenches were used to treat roof runoff while infiltration basins were used to treat runoff from all other impervious surfaces. Table 2 presents Opti-Tool default parameter specifications for the six practices. Analyzing a range of large and small design capacities was intended to facilitate a better understanding of relative costs ($) and maximum load and volume reductions (%) achievable for given design SCM capacities in Tisbury, MA.

The Planning Level Analysis option used the annual pollutant loading rate by land use category to estimate the baseline loads, a unit volume cost to estimate the SCM total cost, SCM performance curves (e.g., relationship between SCM size and associated TN load or stormwater volume reduction) to estimate the load and volume reduction. Local climate data were used to develop the HRU-based annual pollutant loading rates, U.S. EPA (2019) provides further information on the development of the timeseries. The local data was used instead of the default land loading rates provided in the Opti-Tool. However, the analysis did use default SCM unit volume costs and SCM performance curves, which are also provided in the Opti-Tool and use region-specific data. Special attention should be given before using the Planning Level Analysis to make sure that default data are representative of your study area. In this case study, local precipitation data were used from Martha's Vineyard Airport station to develop the HRU timeseries, as described above.

Table 1. Potential stormwater management categories and SCM types in the Opti-Tool

Land Use	Landscape Slope (%)	Within 100 feet of Coastline?	Within 25 feet of Structure?	Soil Group	Management Category	SCM Type(s) in Opti-Tool
Pervious Area	<= 15	Yes	Yes	All	SCM with complicating characteristics	--
		No	No	A/B/C	Infiltration	Surface Infiltration Basin (e.g., Rain Garden)

Land Use	Landscape Slope (%)	Within 100 feet of Coastline?	Within 25 feet of Structure?	Soil Group	Management Category	SCM Type(s) in Opti-Tool
				D	Biofiltration	Biofiltration (e.g., Enhanced Bioretention with ISR and underdrain option)
	> 15	--	--	--	SCM with complicating characteristics	--
Impervious Area	<= 5	Yes	Yes	All	SCM with complicating characteristics	--
		No	No	A/B/C	Infiltration	Infiltration Trench
				D	Shallow filtration	Porous Pavement
	> 5	--	--	--	SCM with complicating characteristics	--

Table 2. Opti-Tool SCM design specifications

General Information	SCM Parameters	Infiltration Trench - A	Infiltration Trench - B	Infiltration Trench - C	Infiltration Basin - A	Infiltration Basin - B	Infiltration Basin - C
SCM Dimensions	Surface Area (ac)	Varies based-on design runoff depth from treated impervious cover					
Surface Storage Configuration	Orifice Height (ft)	0	0	0	0	0	0
	Orifice Diameter (in.)	0	0	0	0	0	0
	Rectangular or Triangular Weir	Rectangular	Rectangular	Rectangular	Rectangular	Rectangular	Rectangular
	Weir Height (ft)/Ponding Depth (ft)	0.5	0.5	0.5	2	2	2
	Crest Width (ft)	30	30	30	30	30	30
Soil Properties	Depth of Soil (ft)	6	6	6	0	0	0
	Soil Porosity (0-1)	0.4	0.4	0.4	0.4	0.4	0.4
	Vegetative Parameter A	0.9	0.9	0.9	0.9	0.9	0.9
	Soil Infiltration (in/hr)	8.27	2.41	1.02	8.27	2.41	1.02
Underdrain Properties	Consider Underdrain Structure?	No	No	No	No	No	No
	Storage Depth (ft)	0	0	0	0	0	0
	Media Void Fraction (0-1)	0	0	0	0	0	0
	Background Infiltration (in/hr)	8.27	2.41	1.02	8.27	2.41	1.02
Cost Parameters	Storage Volume Cost ($/ft3)	$12.49	$12.49	$12.49	$6.24	$6.24	$6.24
Cost Function Adjustment	SCM Development Type	New SCM in Developed Area	New SCM in Developed Area	New SCM in Developed Area	New SCM in Developed Area	New SCM in Developed Area	New SCM in Developed Area
	Cost Adjustment Factor	2	2	2	2	2	2
Decay Rates	TN (1/hr)	0.13	0.13	0.13	0.27	0.27	0.27
Underdrain Removal Rates	TN (%, 0-1)	0	0	0	0	0	0

3 RESULTS: TISBURY GI SCM OPPORTUNITIES

3.1 Town-wide

Figure 1 presents the HRU distribution in Tisbury, MA. Over half the area of the town is forest (Table 3). The majority of residential and commercial land uses are concentrated in the eastern part of the town while agriculture and forested areas are more common in the west. Table 4 presents the HRU area distribution by the zoning district. Residential districts R3A and R50 are the two largest zoning districts, accounting for approximately 63% of the total area of the town. Unsurprisingly the business districts (B2 light business district, B1 business district, and the waterfront commercial) have the most acreage of impervious commercial land while the residential districts have the highest concentration of impervious residential areas. A summary of impervious and pervious areas by zoning district is presented in Table 5. Impervious areas were identified as either being roofs or other impervious areas. Other impervious areas included driveways, parking lots and roads. The distinction allowed for an assessment of different GI SCM opportunities depending on the type of imperviousness. The GI SCM opportunities assessed in this study were infiltration-based, rooftop disconnections were simulated as an infiltration trench, while all other impervious areas were treated using an infiltration basin. The use of two practices, simulated on three soil types, helped to simplify the analysis, however the practices predicted benefits from rooftop disconnection may be achieved by a variety of on-the-ground implementations, including barrels/cisterns that drain slowly to permeable areas.

The maximum area, by zoning district, to implement GI SCM opportunities is presented in Table 6. The data represents existing pervious areas by land use type that may be retrofitted to treat stormwater. Importantly, the information in Table 6 only assesses the maximum area, it does not account for the feasibility of implementation. Therefore, while the majority of pervious land is located in forested areas in the town, it is unlikely that these areas will become the focus of stormwater management solutions. The table provides valuable insight into the existing opportunities within the more developed, urbanized zoning districts and was the basis for the GIS and Opti-Tool analyses to further investigate cost-effective solutions to reducing storm volume and TN loading. Table 7 presents the treated impervious area for the six SCM types by land use and zoning district. The analysis assumed that all impervious areas were treated by GI SCM opportunities. Therefore, while the design size changed incrementally during the analysis, the treated impervious areas remained as shown in Table 7.

Town-wide, the analysis suggests that a 78% reduction in annual stormwater volume and an 81% reduction in annual TN load could be achieved at a cost of approximately $13.54 million (Figure 3). The optimal solutions fall at the inflection point or 'knee' of the curves where reduction has been maximized but costs have not begun to increase substantially. The result is based on the simplifying assumption that all GI SCM opportunities were sized to capture 0.4 inches of runoff, which is close to the optimization-derived result of 0.31-0.35 inches estimated to achieve similar reductions in the catchments for outfalls #2 and #7 (U.S. EPA, 2020). Importantly, the curve also demonstrates that a 100% percent reduction in flow volume and TN reduction should not be expected since only impervious surfaces are treated in the simulation; pervious surfaces are still capable of producing stormflow and contributing to TN loading.

The distribution of the total cost of implementation across zoning districts is presented in Table 8. Overall, planning level analysis requires more money spent on implementation is the residential areas versus the business/commercial districts. This is largely attributed to the distribution of total impervious surfaces (Table 5), there are more acres of impervious surfaces in the larger, residential zones. Table 9 presents the amount each SCM, distributed across the various land uses in the town, disconnects impervious surface, stores and captures stormwater, and removes TN. Table 9 also provides a breakdown of the total costs in Table 8. Rooftop disconnections account for 36% of total costs while treating all other impervious surfaces account for the remaining 64%.

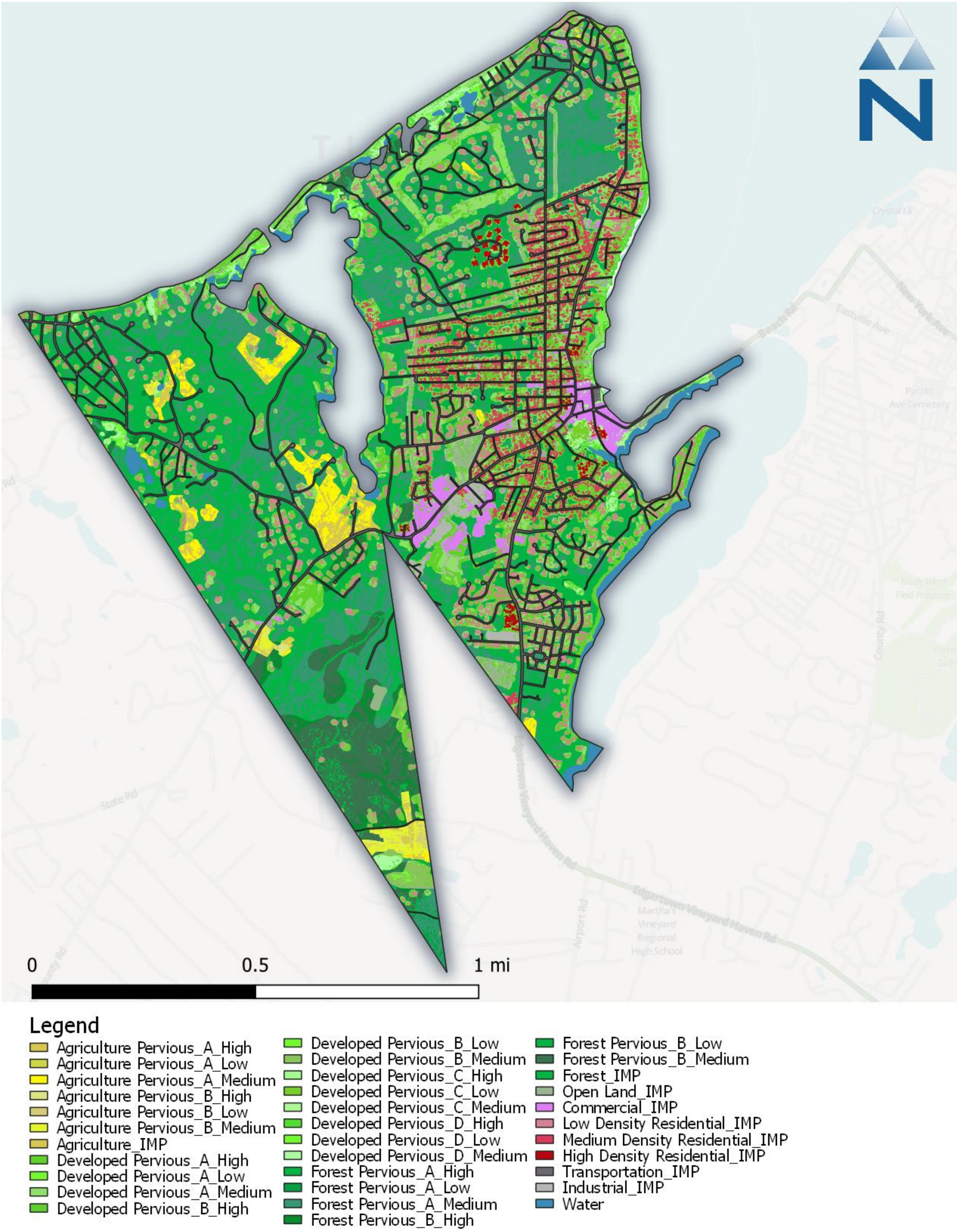

Figure 1. HRU distribution for Tisbury, MA.

Table 3. Land use area distribution in Tisbury zoning districts

Land Use	Total Area by Zoning District (acres)									
	Business District (B1)	Light Business District (B2)	Residential District (R10)	Residential District (R20)	Residential District (R25)	Residential District (R50)	Residential District (R3A)	Lagoon Harbor Park (LHP)	Waterfront Commercial (W/C)	Total
Forest	0.5	36.0	157.7	145.9	160.5	849.4	1,040.6	-	0.8	2,391.5
Agriculture	-	-	1.1	-	0.9	28.2	116.8	-	-	146.9
Commercial	15.3	46.9	16.0	4.7	4.4	3.5	2.0	-	20.0	112.7
Industrial	-	34.8	0.7	6.2	-	-	-	-	-	41.7
Low Density Residential	-	0.7	69.7	142.4	47.0	195.4	95.3	-	1.0	551.5
Medium Density Residential	1.9	2.1	361.4	4.1	97.7	9.2	-	-	1.7	478.1
High Density Residential	0.3	1.4	5.8	5.9	1.6	11.1	-	-	1.5	27.5
Highway	-	-	-	-	0.0	-	-	-	2.7	2.7
Open Land	0.5	4.1	40.5	21.1	32.2	135.4	76.1	4.5	12.2	326.7
Total Area (acres)	**18.5**	**126.0**	**652.9**	**330.4**	**344.3**	**1,232.1**	**1,330.8**	**4.5**	**39.8**	**4,079.3**

Table 4. HRU area distribution in Tisbury Zone districts

HRU-Model	Total Area by Zone District (acres)									
	Business District (B1)	Light Business District (B2)	Residential District (R10)	Residential District (R20)	Residential District (R25)	Residential District (R50)	Residential District (R3A)	Lagoon Harbor Park (LHP)	Waterfront Commercial (W/C)	Total
Forest_IMP	0.1	2.2	11.7	12.8	8.0	56.4	43.7	0.0	0.3	135.3
Agriculture_IMP	0.0	0.0	0.0	0.0	0.1	2.0	6.8	0.0	0.0	8.9
Commercial_IMP	12.4	34.0	8.5	2.9	2.0	1.2	0.6	0.0	15.6	77.2
Industrial_IMP	0.0	14.8	0.5	4.9	0.0	0.0	0.0	0.0	0.0	20.3
Low Density Residential_IMP	0.0	0.3	24.0	42.4	11.4	52.8	21.3	0.0	0.3	152.5
Medium Density Residential_IMP	0.8	0.8	122.6	1.4	27.8	3.0	0.0	0.0	0.7	157.2
High Density Residential_IMP	0.2	0.5	2.2	3.1	0.7	5.9	0.0	0.0	0.8	13.4
Highway_IMP	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.4	2.4
Open Land_IMP	0.0	1.0	11.3	5.3	3.6	9.7	5.9	1.1	7.7	45.7
Developed Pervious_A_Low	0.5	11.7	104.1	32.1	49.9	90.2	27.9	0.0	0.1	316.5
Developed Pervious_A_Medium	1.3	14.0	158.0	59.3	59.5	117.4	47.1	0.0	0.4	457.1
Developed Pervious_A_High	0.9	12.6	53.5	31.8	16.1	38.2	21.8	0.0	0.3	175.1
Developed Pervious_B_Low	0.0	0.1	0.2	0.0	0.0	1.5	17.1	0.0	0.0	18.8
Developed Pervious_B_Medium	0.0	0.1	0.1	0.0	0.0	1.1	13.8	0.0	0.0	15.1
Developed Pervious_B_High	0.0	0.1	0.0	0.0	0.0	0.1	2.5	0.0	0.0	2.7
Developed Pervious_C_Low	1.0	0.0	4.6	0.0	0.1	0.0	0.0	0.6	5.6	11.9
Developed Pervious_C_Medium	0.7	0.0	0.4	0.0	0.2	0.0	0.0	0.8	2.9	4.9
Developed Pervious_C_High	0.2	0.0	0.1	0.0	0.0	0.0	0.0	0.4	0.8	1.5
Developed Pervious_D_Low	0.0	0.0	2.0	0.4	1.6	21.6	10.4	0.6	0.6	37.3
Developed Pervious_D_Medium	0.0	0.0	1.7	0.6	6.5	9.2	4.2	0.6	0.4	23.2
Developed Pervious_D_High	0.0	0.0	0.3	0.4	3.4	2.6	0.9	0.4	0.3	8.3
Forest Pervious_A_Low	0.1	5.8	30.0	27.1	67.2	203.3	196.4	0.0	0.0	529.9
Forest Pervious_A_Medium	0.2	15.0	73.6	59.2	75.2	408.3	399.7	0.0	0.1	1,031.3
Forest Pervious_A_High	0.1	10.6	40.1	46.5	10.2	158.3	171.0	0.0	0.2	437.1
Forest Pervious_B_Low	0.0	0.8	0.8	0.0	0.0	11.4	130.0	0.0	0.0	143.0
Forest Pervious_B_Medium	0.0	1.5	1.1	0.1	0.0	9.5	81.7	0.0	0.0	94.0
Forest Pervious_B_High	0.0	0.1	0.4	0.1	0.0	2.2	18.1	0.0	0.0	21.0
Agriculture Pervious_A_Low	0.0	0.0	0.8	0.0	0.3	7.0	27.1	0.0	0.0	35.2

HRU-Model	Total Area by Zone District (acres)									
	Business District (B1)	Light Business District (B2)	Residential District (R10)	Residential District (R20)	Residential District (R25)	Residential District (R50)	Residential District (R3A)	Lagoon Harbor Park (LHP)	Waterfront Commercial (W/C)	Total
Agriculture Pervious_A_Medium	0.0	0.0	0.3	0.0	0.5	15.4	42.4	0.0	0.0	58.5
Agriculture Pervious_A_High	0.0	0.0	0.0	0.0	0.0	3.7	11.1	0.0	0.0	14.9
Agriculture Pervious_B_Low	0.0	0.0	0.0	0.0	0.0	0.0	21.5	0.0	0.0	21.5
Agriculture Pervious_B_Medium	0.0	0.0	0.0	0.0	0.0	0.0	6.9	0.0	0.0	6.9
Agriculture Pervious_B_High	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	1.0
Total Area (acres)	**18.5**	**126.0**	**652.9**	**330.4**	**344.3**	**1,232.1**	**1,330.8**	**4.5**	**39.8**	**4,079.3**

Note: The color scale represents the lowest (blue) to the highest (red) footprint of a model HRU across the zoning districts (color gradient varies horizontally).

Table 5. Pervious and impervious areas in Tisbury

Description	Total Area (acres)	Impervious Area (acres)			Pervious Area (acres)
		Roofs	Other Impervious	Total Impervious	
Business District (B1)	18.53	4.44	9.04	13.48	5.04
Light Business District (B2)	125.99	8.72	44.93	53.65	72.33
Residential District (R10)	652.92	49.12	131.77	180.89	472.03
Residential District (R20)	330.40	15.46	57.31	72.77	257.63
Residential District (R25)	344.27	16.46	37.13	53.60	290.67
Residential District (R50)	1,232.14	24.40	106.60	131.01	1,101.13
Residential District (R3A)	1,330.80	10.46	67.85	78.31	1,252.48
Lagoon Harbor Park (LHP)	4.53	0.02	1.12	1.15	3.38
Waterfront Commercial (W/C)	39.75	6.30	21.58	27.88	11.87
Total Area (acres)	**4,079.32**	**135.40**	**477.34**	**612.74**	**3,466.58**

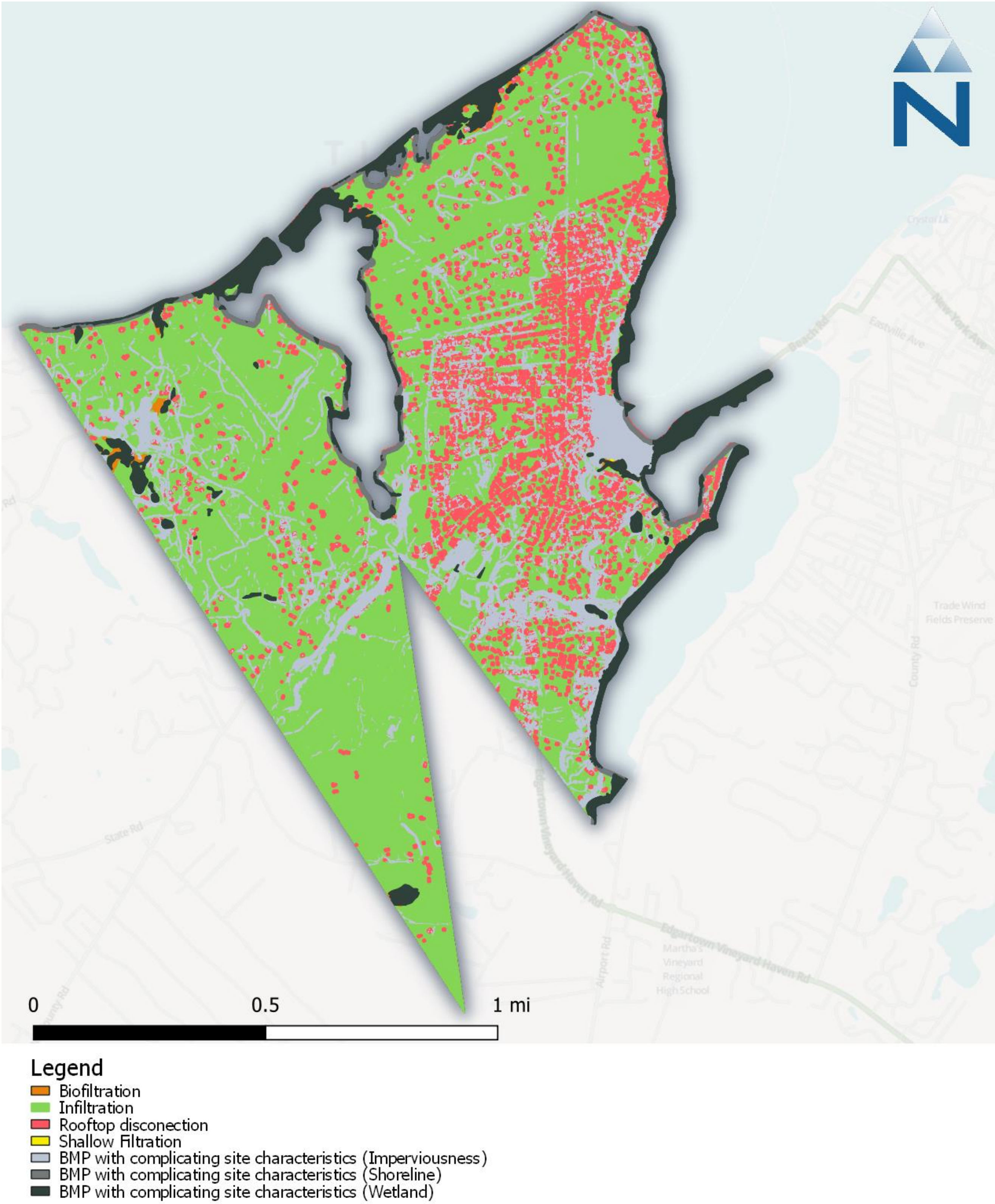

Figure 2. GI SCM opportunities in Tisbury, MA.

Table 6. Potential infiltration GI SCM opportunity areas (maximum footprints) by Tisbury zoning district.

Land Use Group	HSG	Pervious Opportunity Areas for Infiltration GI SCM in Tisbury by Zoning District (acres)									
		Business District (B1)	**Light Business District (B2)**	**Residential District (R10)**	**Residential District (R20)**	**Residential District (R25)**	**Residential District (R50)**	**Residential District (R3A)**	**Lagoon Harbor Park (LHP)**	**Waterfront Commercial (W/C)**	Total
Forest	A	0.41	31.39	143.69	131.90	152.18	754.68	753.24	-	0.35	1,967.83
	B	-	2.41	1.37	-	-	10.12	225.95	-	-	239.85
	C	0.04	-	0.32	-	-	-	-	-	-	0.35
Agriculture	A	-	-	1.05	-	0.79	26.01	79.52	-	-	107.37
	B	-	-	-	-	-	0.05	27.55	-	-	27.60
	C	-	-	-	-	-	-	-	-	-	0.00
Commercial	A	1.42	12.46	7.38	1.79	2.14	2.20	1.11	-	-	28.49
	B	-	0.20	-	-	-	0.01	0.28	-	-	0.49
	C	1.51	-	0.10	-	0.30	-	-	-	3.70	5.61
Industrial	A	-	19.72	0.15	1.34	-	-	-	-	-	21.21
	B	-	-	-	-	-	-	-	-	-	0.00
	C	-	-	-	-	-	-	-	-	-	0.00
Low Density Residential	A	-	0.41	45.21	95.49	32.30	134.43	55.00	-	0.59	363.44
	B	-	-	0.24	-	-	1.86	10.87	-	-	12.96
	C	-	-	-	-	-	-	-	-	-	0.00
Medium Density Residential	A	1.15	1.29	238.82	2.68	69.05	5.44	-	-	-	318.43
	B	-	-	-	-	-	-	-	-	-	0.00
	C	-	-	0.00	-	0.00	-	-	-	1.00	1.01
High Density Residential	A	0.07	0.92	3.57	2.84	0.84	5.24	-	-	-	13.47
	B	-	-	-	-	-	-	-	-	-	0.00
	C	-	-	-	-	-	-	-	-	0.63	0.63
Highway	A	-	-	-	-	-	-	-	-	-	0.00
	B	-	-	-	-	-	-	-	-	-	0.00
	C	-	-	-	-	0.00	-	-	-	0.17	0.17
Open Land	A	0.02	3.06	19.73	6.52	6.05	56.06	14.50	-	0.00	105.94
	B	-	-	-	-	-	0.07	20.71	-	-	20.78
	C	0.43	-	4.62	-	0.00	-	-	-	0.97	6.02
Total	**A**	**3.07**	**69.25**	**459.61**	**242.55**	**263.35**	**984.05**	**903.37**	**-**	**0.94**	**2,926.20**
	B	**-**	**2.61**	**1.61**	**-**	**-**	**12.10**	**285.36**	**-**	**-**	**301.68**
	C	**1.97**	**-**	**5.03**	**-**	**0.30**	**-**	**-**	**-**	**6.47**	**13.78**

Table 7. Infiltration GI SCM treated impervious area (impervious cover disconnected) for Tisbury, MA

Land Use Group	SCM Type	HSG	Treated Impervious Area for Infiltration GI SCM in Tisbury by Zoning District (acres)									
			Business District (B1)	Light Business District (B2)	Residential District (R10)	Residential District (R20)	Residential District (R25)	Residential District (R50)	Residential District (R3A)	Lagoon Harbor Park (LHP)	Waterfront Commercial (W/C)	Total
Forest	Infiltration Trench (Rooftop disconnected)	A	0.045	0.066	1.669	0.810	0.631	1.907	0.752	-	-	5.879
		B	-	0.005	0.016	-	-	0.026	0.226	-	-	0.272
		C	0.004	-	0.004	-	-	-	-	-	-	0.008
	Infiltration Basin (Other IC disconnected)	A	0.053	1.980	9.901	12.024	7.361	53.779	32.876	-	0.293	118.268
		B	-	0.152	0.095	-	-	0.721	9.862	-	-	10.830
		C	0.005	-	0.022	-	-	-	-	-	-	0.026
Agriculture	Infiltration Trench (Rooftop disconnected)	A	-	-	0.006	-	-	0.083	0.697	-	-	0.786
		B	-	-	-	-	-	0.000	0.241	-	-	0.242
		C	-	-	-	-	-	-	-	-	-	-
	Infiltration Basin (Other IC disconnected)	A	-	-	-	-	0.114	1.893	4.343	-	-	6.351
		B	-	-	-	-	-	0.003	1.505	-	-	1.508
		C	-	-	-	-	-	-	-	-	-	-
Commercial	Infiltration Trench (Rooftop disconnected)	A	1.957	6.020	2.197	0.613	0.504	0.390	0.125	-	-	11.805
		B	-	0.097	-	-	-	0.002	0.031	-	-	0.130
		C	2.087	-	0.029	-	0.070	-	-	-	3.825	6.012
	Infiltration Basin (Other IC disconnected)	A	4.036	27.418	6.212	2.280	1.228	0.848	0.360	-	-	42.382
		B	-	0.442	-	-	-	0.004	0.090	-	-	0.536
		C	4.304	-	0.083	-	0.172	-	-	-	11.798	16.357
Industrial	Infiltration Trench (Rooftop disconnected)	A	-	2.188	0.031	0.386	-	-	-	-	-	2.605
		B	-	-	-	-	-	-	-	-	-	-
		C	-	-	-	-	-	-	-	-	-	-
	Infiltration Basin (Other IC disconnected)	A	-	12.662	0.497	4.521	-	-	-	-	-	17.679
		B	-	-	-	-	-	-	-	-	-	-
		C	-	-	-	-	-	-	-	-	-	-
Low Density Residential	Infiltration Trench (Rooftop disconnected)	A	-	0.030	5.491	12.053	4.065	18.279	6.768	-	0.017	46.704
		B	-	-	0.029	-	-	0.253	1.337	-	-	1.619
		C	-	-	-	-	-	-	-	-	-	0.000
	Infiltration Basin (Other IC disconnected)	A	-	0.228	18.402	30.302	7.355	33.765	11.037	-	0.305	101.394
		B	-	-	0.096	-	-	0.468	2.180	-	-	2.744
		C	-	-	-	-	-	-	-	-	-	-

Land Use Group	SCM Type	HSG	Treated Impervious Area for Infiltration GI SCM in Tisbury by Zoning District (acres)									
			Business District (B1)	**Light Business District (B2)**	**Residential District (R10)**	**Residential District (R20)**	**Residential District (R25)**	**Residential District (R50)**	**Residential District (R3A)**	**Lagoon Harbor Park (LHP)**	**Waterfront Commercial (W/C)**	Total
Medium Density Residential	Infiltration Trench (Rooftop disconnected)	A	0.254	0.109	38.645	0.305	10.635	0.781	-	-	-	50.729
		B	-	-	-	-	-	-	-	-	-	-
		C	-	-	0.000	-	0.000	-	-	-	0.258	0.258
	Infiltration Basin (Other IC disconnected)	A	0.504	0.740	83.954	1.119	17.123	2.256	-	-	-	105.695
		B	-	-	-	-	-	-	-	-	-	0.000
		C	-	-	0.000	-	0.000	-	-	-	0.483	0.484
High Density Residential	Infiltration Trench (Rooftop disconnected)	A	0.097	0.163	0.924	0.759	0.332	2.261	-	-	-	4.537
		B	-	-	-	-	-	-	-	-	-	-
		C	0.001	-	-	-	-	-	-	-	0.226	0.227
	Infiltration Basin (Other IC disconnected)	A	0.098	0.316	1.310	2.299	0.407	3.598	-	-	-	8.028
		B	-	-	-	-	-	-	-	-	-	-
		C	0.001	-	-	-	-	-	-	-	0.599	0.600
Highway	Infiltration Trench (Rooftop disconnected)	A	-	-	-	-	-	-	-	-	-	-
		B	-	-	-	-	-	-	-	-	-	-
		C	-	-	-	-	-	-	-	-	0.211	0.211
	Infiltration Basin (Other IC disconnected)	A	-	-	-	-	-	-	-	-	-	-
		B	-	-	-	-	-	-	-	-	-	-
		C	-	-	-	-	0.012	-	-	-	2.159	2.171
Open Land	Infiltration Trench (Rooftop disconnected)	A	0.000	0.044	0.066	0.531	0.226	0.421	0.115	-	0.000	1.403
		B	-	-	-	-	-	0.001	0.165	-	-	0.165
		C	0.000	-	0.015	-	0.000	-	-	-	1.766	1.782
	Infiltration Basin (Other IC disconnected)	A	0.002	0.994	9.071	4.768	3.358	9.257	2.306	-	0.002	29.757
		B	-	-	-	-	-	0.011	3.295	-	-	3.307
		C	0.040	-	2.123	-	0.001	-	-	-	5.942	8.104
Total	**Infiltration Trench (Rooftop disconnected)**	**A**	**2.353**	**8.620**	**49.029**	**15.457**	**16.393**	**24.122**	**8.457**	**-**	**0.017**	**124.448**
		B	**-**	**0.102**	**0.045**	**-**	**-**	**0.281**	**2.000**	**-**	**-**	**2.428**
		C	**2.092**	**-**	**0.049**	**-**	**0.071**	**-**	**-**	**-**	**6.286**	**8.497**
	Infiltration Basin (Other IC disconnected)	**A**	**4.692**	**44.337**	**129.347**	**57.313**	**36.947**	**105.397**	**50.922**	**-**	**0.600**	**429.555**
		B	**-**	**0.594**	**0.191**	**-**	**-**	**1.207**	**16.932**	**-**	**-**	**18.924**
		C	**4.348**	**-**	**2.228**	**-**	**0.185**	**-**	**-**	**-**	**20.981**	**27.743**

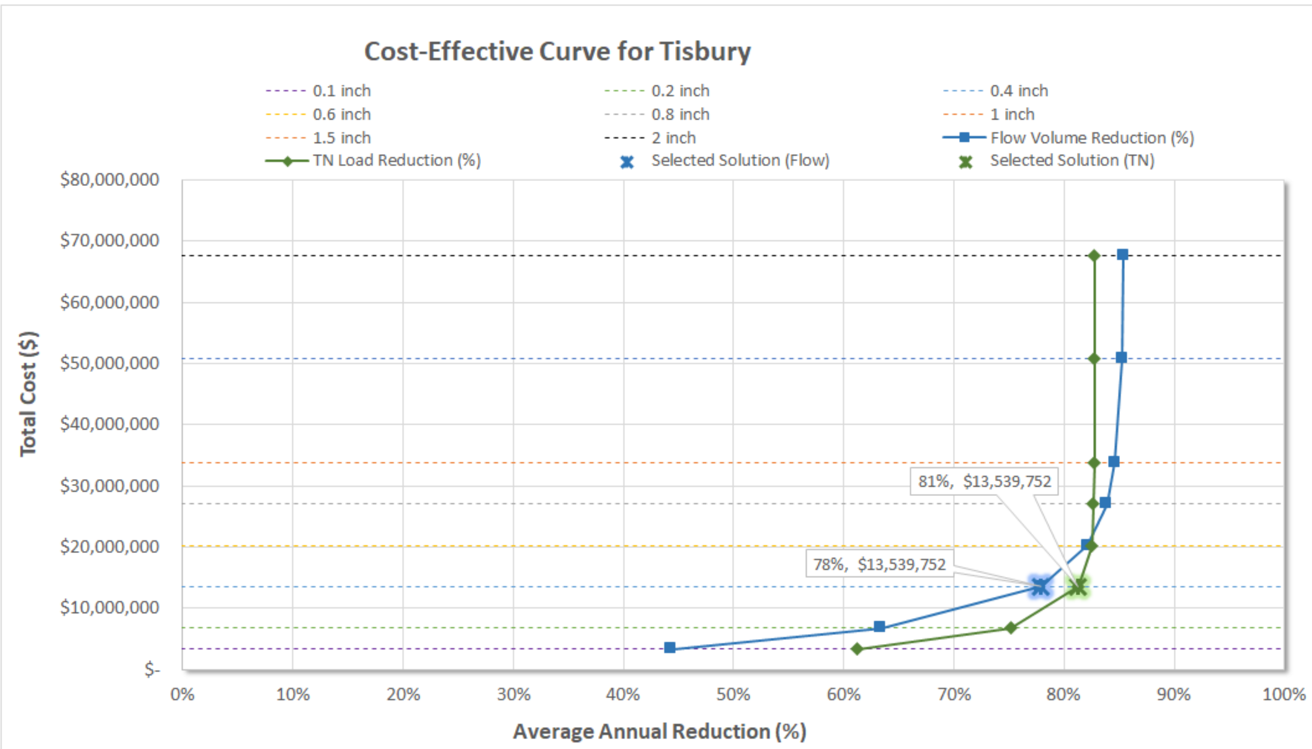

Figure 3. Cost effectiveness curves for incremental sizing of GI SCM opportunities in Tisbury, MA.

Table 8. Costs by development zone to achieve town-wide reductions of 78% and 81% in stormwater volume and TN loading, respectively for the town of Tisbury, MA

Development Zone									
B1 Business District	B2 Light Business District	LHP Lagoon Harbor Park	R3A Residential District	R10 Residential District	R20 Residential District	R25 Residential District	R50 Residential District	WC Waterfront Commercial District	Total
325038	$1,130,554	--	$1,608,886	$4,169,444	$1,599,198	$1,270,024	$2,816,910	$619,698	$13,539,752

Note: The color scale represents the least expensive (blue) to most expensive (red).

Table 9. Infiltration GI SCM Solution (0.4 inch) Tisbury, MA

Land Use Group	SCM Type	HSG	Infiltration GI SCM Solution (0.4 inch) for Tisbury				
			IC Disconnected (acres)	Storage Capacity (gallons)	Flow Volume Captured (gallons/yr)	TN Load Removed (lbs/yr)	SCM Cost ($)
Forest	Infiltration Trench (Rooftop disconnected)	A	5.879	63,858	5,547,883	46.176	$213,242
		B	0.272	2,956	217,188	2.072	$9,872
		C	0.008	82	5,231	0.056	$274
	Infiltration Basin (Other IC disconnected)	A	118.268	1,284,599	112,569,011	938.393	$2,143,140
		B	10.830	117,630	8,586,227	82.456	$196,246
		C	0.026	286	17,597	0.194	$478
Agriculture	Infiltration Trench (Rooftop disconnected)	A	0.786	8,542	742,087	6.177	$28,524
		B	0.242	2,624	192,750	1.839	$8,762
		C	-	-	-	-	-
	Infiltration Basin (Other IC disconnected)	A	6.351	68,978	6,044,544	50.388	$115,078
		B	1.508	16,378	1,195,480	11.481	$27,324
		C	-	-	-	-	-
Commercial	Infiltration Trench (Rooftop disconnected)	A	11.805	128,218	11,139,465	133.671	$428,164
		B	0.130	1,413	103,768	1.428	$4,716
		C	6.012	65,299	4,178,287	63.909	$218,058
	Infiltration Basin (Other IC disconnected)	A	42.382	460,348	40,340,116	484.825	$768,014
		B	0.536	5,820	424,851	5.882	$9,710
		C	16.357	177,664	10,934,736	173.881	$296,404
Industrial	Infiltration Trench (Rooftop disconnected)	A	2.605	28,300	2,458,676	29.504	$94,504
		B	-	-	-	-	-
		C	-	-	-	-	-
	Infiltration Basin (Other IC disconnected)	A	17.679	192,023	16,826,934	202.233	$320,358
		B	-	-	-	-	-
		C	-	-	-	-	-
Low Density Residential	Infiltration Trench (Rooftop disconnected)	A	46.704	507,285	44,072,479	486.545	$1,693,998
		B	1.619	17,585	1,291,823	16.350	$58,722
		C	-	-	-	-	-
	Infiltration Basin (Other IC disconnected)	A	101.394	1,101,316	96,507,964	1,067.068	$1,837,362
		B	2.744	29,805	2,175,576	27.711	$49,724
		C	-	-	-	-	-
Medium Density Residential	Infiltration Trench (Rooftop disconnected)	A	50.729	551,008	47,871,095	528.481	$1,840,004
		B	-	-	-	-	-
		C	0.258	2,806	179,539	2.526	$9,370
	Infiltration Basin (Other IC disconnected)	A	105.695	1,148,037	100,602,069	1,112.336	$1,915,308
		B	-	-	-	-	-
		C	0.484	5,254	323,387	4.731	$8,766
High Density Residential	Infiltration Trench (Rooftop disconnected)	A	4.537	49,279	4,281,291	47.264	$164,558
		B	-	-	-	-	-
		C	0.227	2,461	157,440	2.215	$8,216
	Infiltration Basin (Other IC disconnected)	A	8.028	87,201	7,641,373	84.489	$145,480
		B	-	-	-	-	-
		C	0.600	6,519	401,210	5.869	$10,876

Land Use Group	SCM Type	HSG	Infiltration GI SCM Solution (0.4 inch) for Tisbury				
			IC Disconnected (acres)	Storage Capacity (gallons)	Flow Volume Captured (gallons/yr)	TN Load Removed (lbs/yr)	SCM Cost ($)
Highway	Infiltration Trench (Rooftop disconnected)	A	-	-	-	-	-
		B	-	-	-	-	-
		C	0.211	2,289	146,493	1.341	$7,646
	Infiltration Basin (Other IC disconnected)	A	-	-	-	-	-
		B	-	-	-	-	-
		C	2.171	23,582	1,451,376	13.818	$39,342
Open Land	Infiltration Trench (Rooftop disconnected)	A	1.403	15,238	1,323,877	11.019	$50,886
		B	0.165	1,793	131,722	1.257	$5,988
		C	1.782	19,356	1,238,500	13.139	$64,636
	Infiltration Basin (Other IC disconnected)	A	29.757	323,215	28,323,260	236.107	$539,232
		B	3.307	35,915	2,621,534	25.175	$59,918
		C	8.104	88,028	5,417,858	59.757	$146,860
Total	**Infiltration Trench (Rooftop disconnected)**	**A**	**124.448**	**1,351,727**	**117,436,853**	**1,288.837**	**$4,513,878**
		B	**2.428**	**26,371**	**1,937,250**	**22.946**	**$88,060**
		C	**8.497**	**92,293**	**5,905,491**	**83.187**	**$308,196**
	Infiltration Basin (Other IC disconnected)	**A**	**429.555**	**4,665,717**	**408,855,270**	**4,175.840**	**$7,783,972**
		B	**18.924**	**205,548**	**15,003,669**	**152.706**	**$342,922**
		C	**27.743**	**301,332**	**18,546,165**	**258.250**	**$502,724**

A summary of the results of the town-wide analysis is presented in Table 10. The residential zoning districts which encompass a majority of the area of the town, unsurprisingly also had the highest baseline stormwater volume (gallons/yr) and TN loading (lbs/yr). However, commercial and industrial HRUs generated more TN per acre than in residential areas (U.S. EPA, 2019). The overall cost ($/gallon) to reduce stormwater volume was $0.01, a penny per gallon, however, when treating with millions of gallons of runoff, costs can still add up quickly. The total cost for removing TN ($/lb) was $2,264. Unlike surface runoff, which all impervious surfaces generate identically (all impervious areas convert the same amount of rainfall to runoff), TN loading differs by land use type. The cost-effectiveness of GI SCM solutions tends to increase with TN runoff concentrations. Based on annual TN loading and stormwater volume (Table 10) 99,066 gallons of stormwater needs to be treated, at a 100% removal rate, to remove 1 lb of TN. Therefore, if TN concentrations were higher in the runoff, it would take less volume, and therefore less money, to remove a pound of TN. Local water quality monitoring data could help inform these costs.

The following subsections describe the HRU composition and associated opportunities for GI SCM implementation within each of the town's nine zoning districts.

Table 10. Summary table for baseline conditions, costs, and effectiveness of the GI SCM solution (0.4 inch) for Tisbury, MA

	Results Summary by Zone District									
	Business District (B1)	Light Business District (B2)	Residential District (R10)	Residential District (R20)	Residential District (R25)	Residential District (R50)	Residential District (R3A)	Lagoon Harbor Park (LHP)	Waterfront Commercial (W/C)	Total
Impervious Cover Disconnected (acre)	13.485	53.653	180.888	72.770	53.595	131.007	78.311	-	27.884	612
Baseline Average Flow Volume (gallons/yr)	14,086,926	56,021,249	193,152,326	79,092,890	62,856,054	166,124,955	124,907,630	1,926,511	30,247,094	728,415,636
Baseline Average TN Load (lbs/yr)	159.679	622.274	1,984.825	789.530	635.617	1,579.136	1,253.917	19.411	307.774	7,352
Flow Volume Removed (gallons/yr)	11,046,984	50,887,420	171,090,623	69,136,916	50,808,604	124,262,584	71,469,201	-	18,982,366	567,684,698
TN Load Removed (lbs/yr)	147.406	599.656	1,845.838	724.391	533.597	1,200.446	671.385	-	259.047	5,982
Total Cost for Selected Solution ($)	$325,038	$1,130,554	$4,169,444	$1,599,198	$1,270,024	$2,816,910	$1,608,886	-	$619,698	#########
Cost per Gallon Flow Removed ($)	$0.03	$0.02	$0.02	$0.02	$0.02	$0.02	$0.02	-	$0.03	$0.02
Cost per Pound TN Removed ($)	$2,206	$1,886	$2,258	$2,208	$2,380	$2,346	$2,396	-	$2,392	$2,264

3.2 B1 Business District

Figure 4 presents the HRUs for the B1 Business District zone. Impervious surfaces make up a high proportion of the area, with 73% of the land consisting of rooftops and other impervious surfaces. The zone has relatively limited opportunities for GI SCM implementation (Figure 5). A 0.4 inch design criteria achieved a 78% reduction in flow volume and a 92% reduction in TN loading (Figure 6). The TN reductions were achieved at a cost of $325,037.

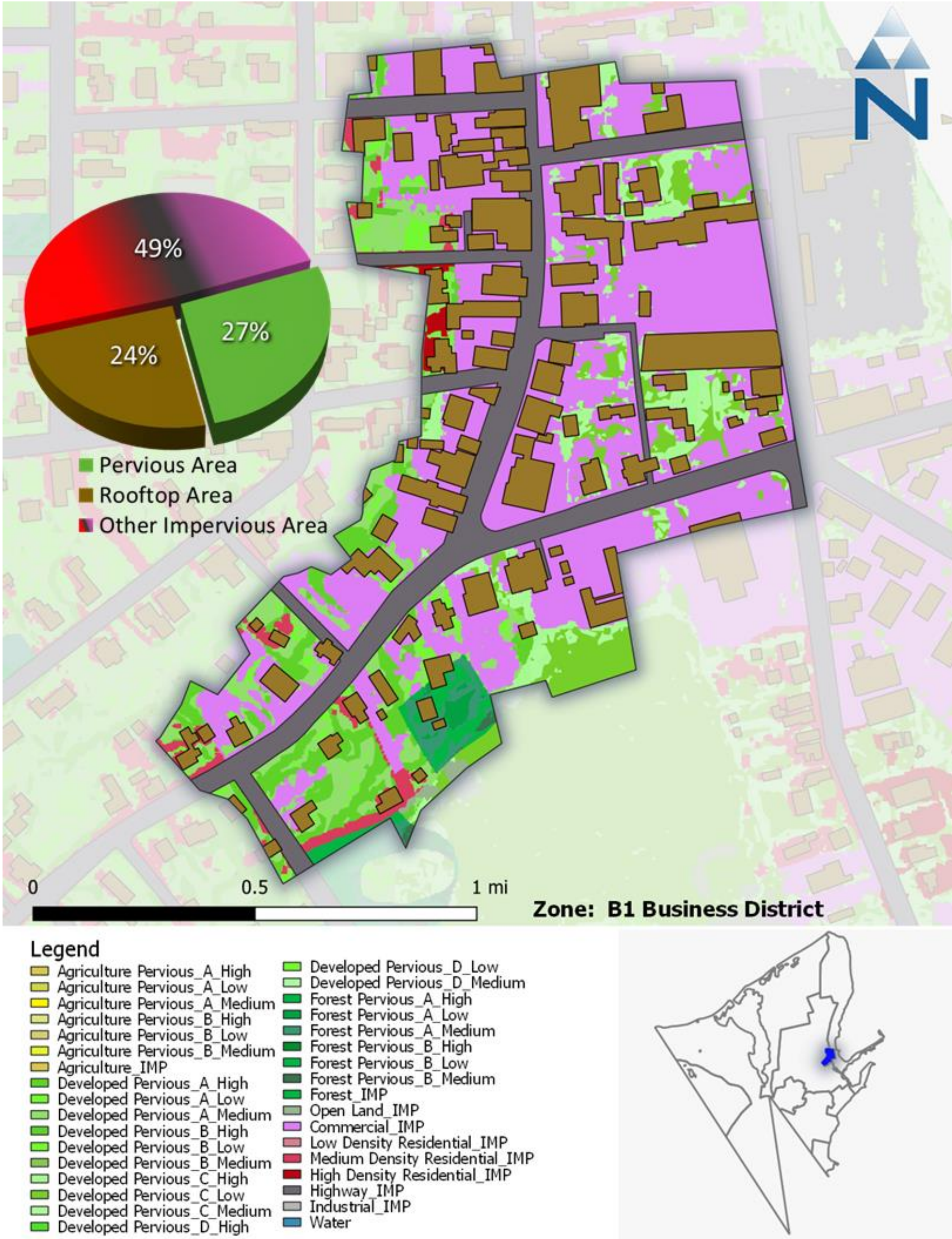

Figure 4. HRU distribution in the B1 Business District Zone of Tisbury, MA.

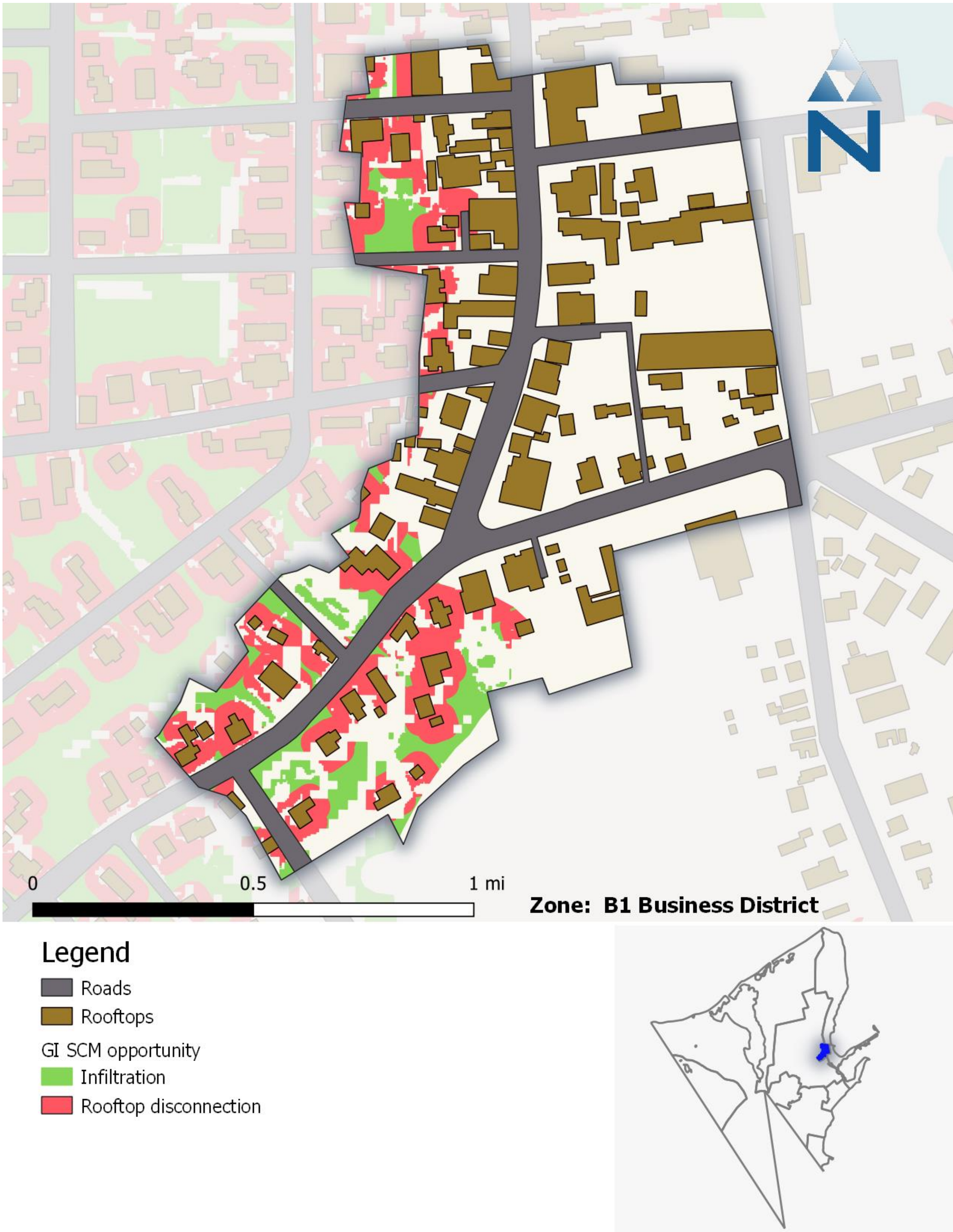

Figure 5. GI SCM opportunities in the B1 Business District Zone of Tisbury, MA.

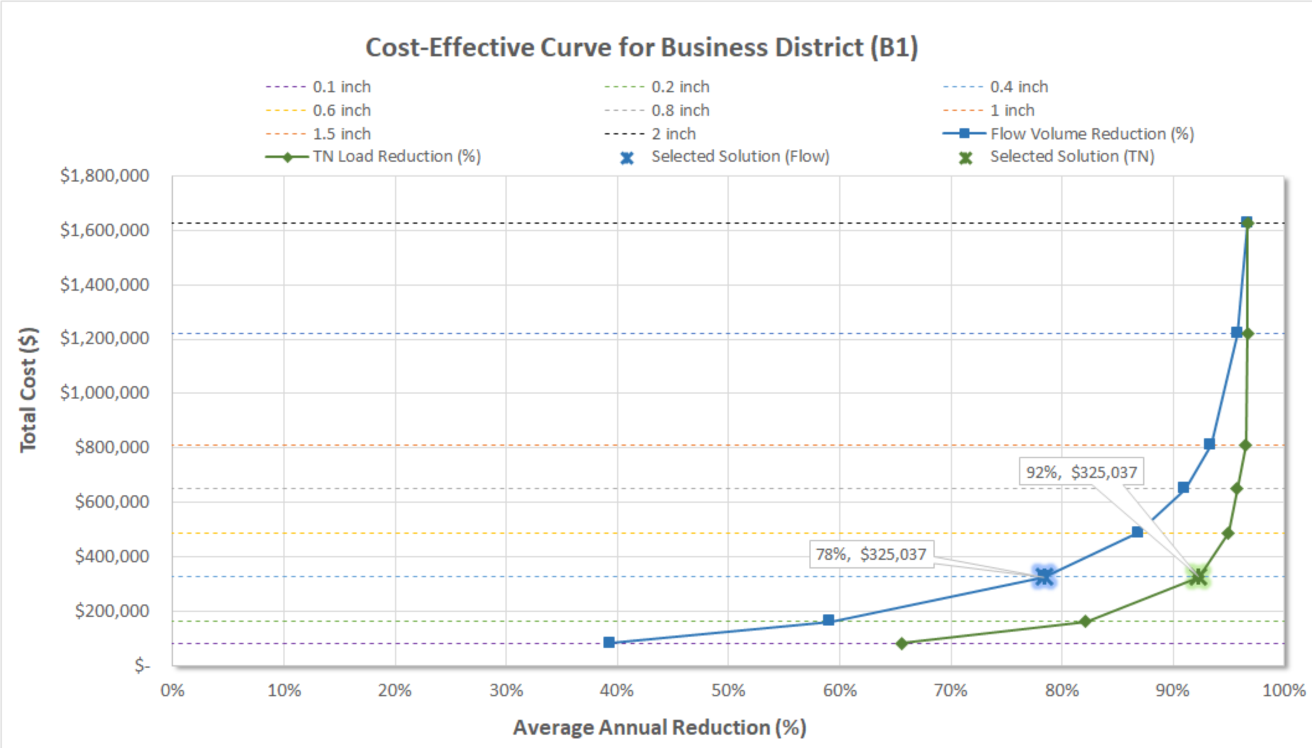

Figure 6. Cost effectiveness curves for incremental sizing of GI SCM opportunities in the B1 Business District Zone of Tisbury, MA.

Table 11. Infiltration GI SCM Solution (0.4 inch) for the B1 Business District of Tisbury, MA

Land Use Group	SCM Type	HSG	Infiltration GI SCM Solution (0.4 inch) for Business District (B1) in Tisbury				
			IC Disconnected (acres)	Storage Capacity (gallons)	Flow Volume Captured (gallons/yr)	TN Load Removed (lbs/yr)	SCM Cost ($)
Forest	Infiltration Trench (Rooftop disconnected)	A	0.045	484	42,064	0.350	$1,616
		B	-	-	-	-	-
		C	0.004	42	2,681	0.028	$140
	Infiltration Basin (Other IC disconnected)	A	0.053	571	50,004	0.417	$952
		B	-	-	-	-	-
		C	0.005	49	3,039	0.034	$82
Agriculture	Infiltration Trench (Rooftop disconnected)	A	-	-	-	-	-
		B	-	-	-	-	-
		C	-	-	-	-	-
	Infiltration Basin (Other IC disconnected)	A	-	-	-	-	-
		B	-	-	-	-	-
		C	-	-	-	-	-
Commercial	Infiltration Trench (Rooftop disconnected)	A	1.957	21,257	1,846,809	22.161	$70,986
		B	-	-	-	-	-
		C	2.087	22,666	1,450,334	22.184	$75,690
	Infiltration Basin (Other IC disconnected)	A	4.036	43,838	3,841,518	46.169	$73,136
		B	-	-	-	-	-
		C	4.304	46,744	2,876,950	45.748	$77,984
Industrial	Infiltration Trench (Rooftop disconnected)	A	-	-	-	-	-
		B	-	-	-	-	-
		C	-	-	-	-	-
	Infiltration Basin (Other IC disconnected)	A	-	-	-	-	-
		B	-	-	-	-	-
		C	-	-	-	-	-
Low Density Residential	Infiltration Trench (Rooftop disconnected)	A	-	-	-	-	-
		B	-	-	-	-	-
		C	-	-	-	-	-
	Infiltration Basin (Other IC disconnected)	A	-	-	-	-	-
		B	-	-	-	-	-
		C	-	-	-	-	-
Medium Density Residential	Infiltration Trench (Rooftop disconnected)	A	0.254	2,762	239,945	2.649	$9,222
		B	-	-	-	-	-
		C	-	-	-	-	-
	Infiltration Basin (Other IC disconnected)	A	0.504	5,470	479,331	5.300	$9,126
		B	-	-	-	-	-
		C	-	-	-	-	-
High Density Residential	Infiltration Trench (Rooftop disconnected)	A	0.097	1,058	91,935	1.015	$3,534
		B	-	-	-	-	-
		C	0.001	7	470	0.007	$24
	Infiltration Basin (Other IC disconnected)	A	0.098	1,064	93,196	1.030	$1,774
		B	-	-	-	-	-
		C	0.001	7	455	0.007	$12

Land Use Group	SCM Type	HSG	Infiltration GI SCM Solution (0.4 inch) for Business District (B1) in Tisbury				
			IC Disconnected (acres)	Storage Capacity (gallons)	Flow Volume Captured (gallons/yr)	TN Load Removed (lbs/yr)	SCM Cost ($)
Highway	Infiltration Trench (Rooftop disconnected)	A	-	-	-	-	-
		B	-	-	-	-	-
		C	-	-	-	-	-
	Infiltration Basin (Other IC disconnected)	A	-	-	-	-	-
		B	-	-	-	-	-
		C	-	-	-	-	-
Open Land	Infiltration Trench (Rooftop disconnected)	A	0.000	0	10	0.000	$0
		B	-	-	-	-	-
		C	0.000	3	165	0.002	$8
	Infiltration Basin (Other IC disconnected)	A	0.002	19	1,652	0.014	$32
		B	-	-	-	-	-
		C	0.040	429	26,427	0.291	$716
Total	**Infiltration Trench (Rooftop disconnected)**	**A**	**2.353**	**25,562**	**2,220,763**	**26.175**	**$85,358**
		B	**-**	**-**	**-**	**-**	-
		C	**2.092**	**22,718**	**1,453,649**	**22.220**	**$75,864**
	Infiltration Basin (Other IC disconnected)	**A**	**4.692**	**50,961**	**4,465,702**	**52.930**	**$85,020**
		B	**-**	**-**	**-**	**-**	-
		C	**4.348**	**47,230**	**2,906,870**	**46.080**	**$78,796**

3.3 B2 Light Business District

Figure 7 presents the HRUs for the B1 Business District zone. The majority of land in the district is pervious surfaces, with 43% of the land consisting of rooftops and other impervious surfaces. Figure 8 presents the GI SCM opportunities for the area. A 0.4 inch design criteria achieved a 91% reduction in flow volume and a 96% reduction in TN loading (Figure 9). The reductions were achieved at a cost of $1,130,554.

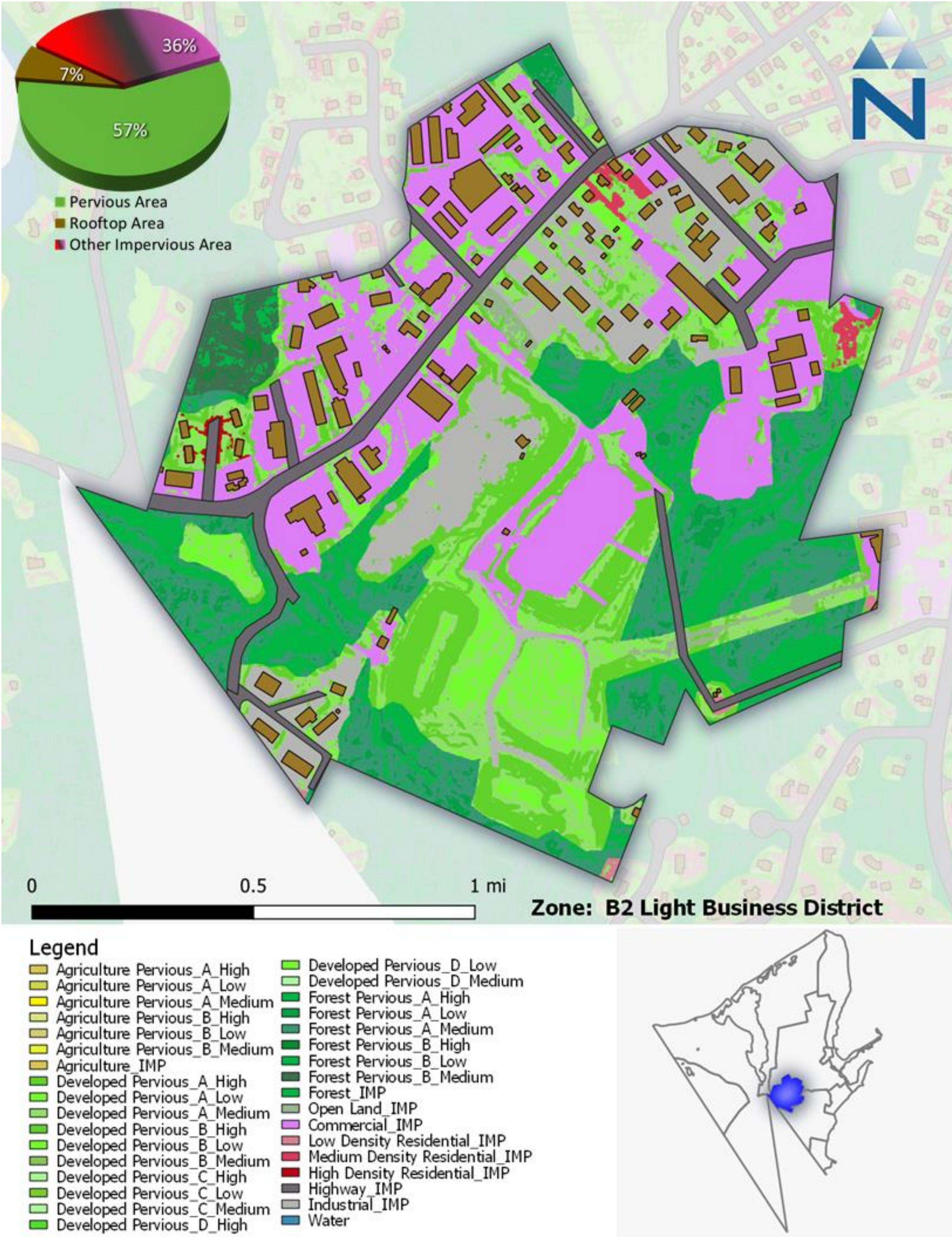

Figure 7. HRU distribution in the B2 Light Business District Zone of Tisbury, MA.

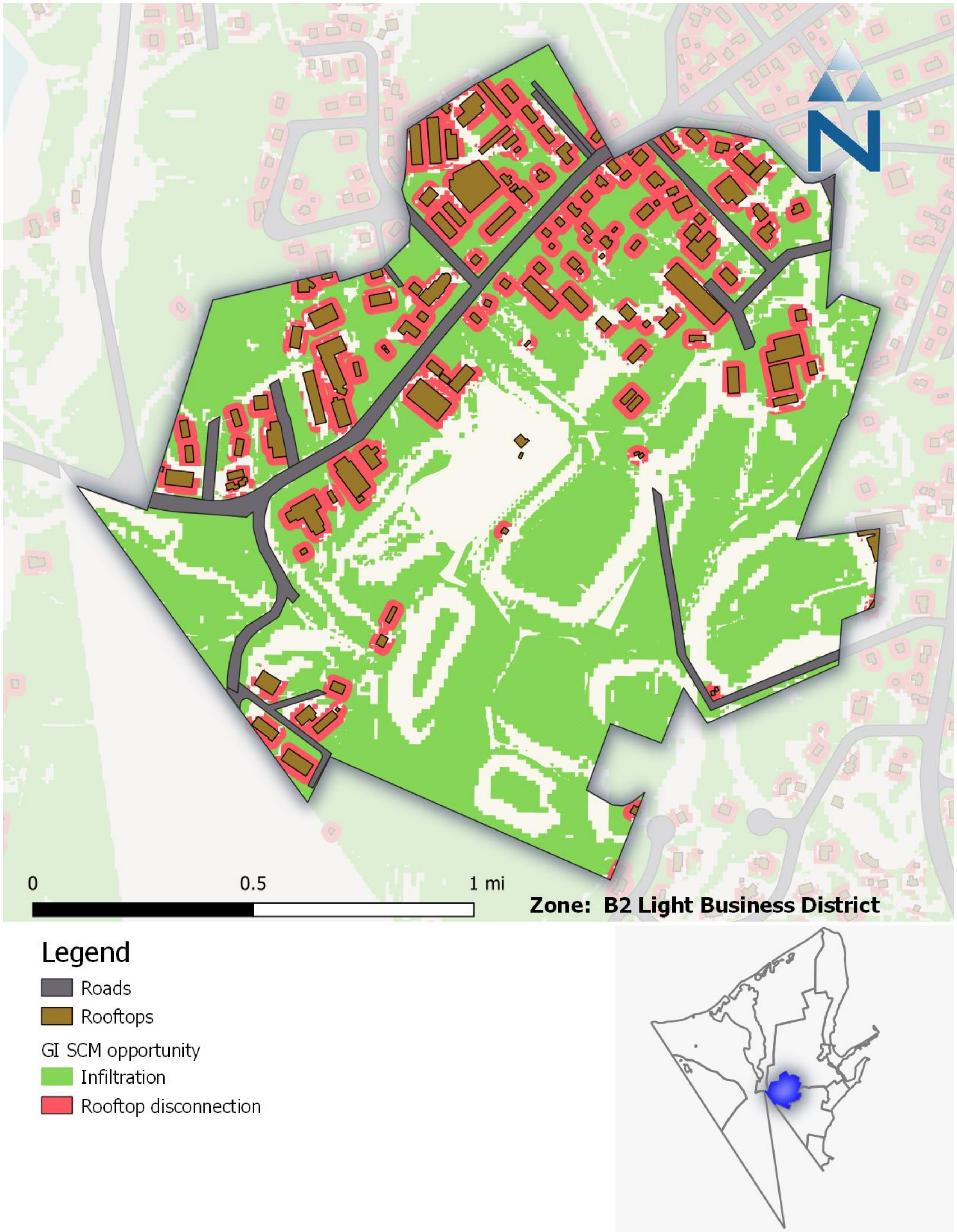

Figure 8. GI SCM opportunities in the B2 Light Business District Zone of Tisbury, MA.

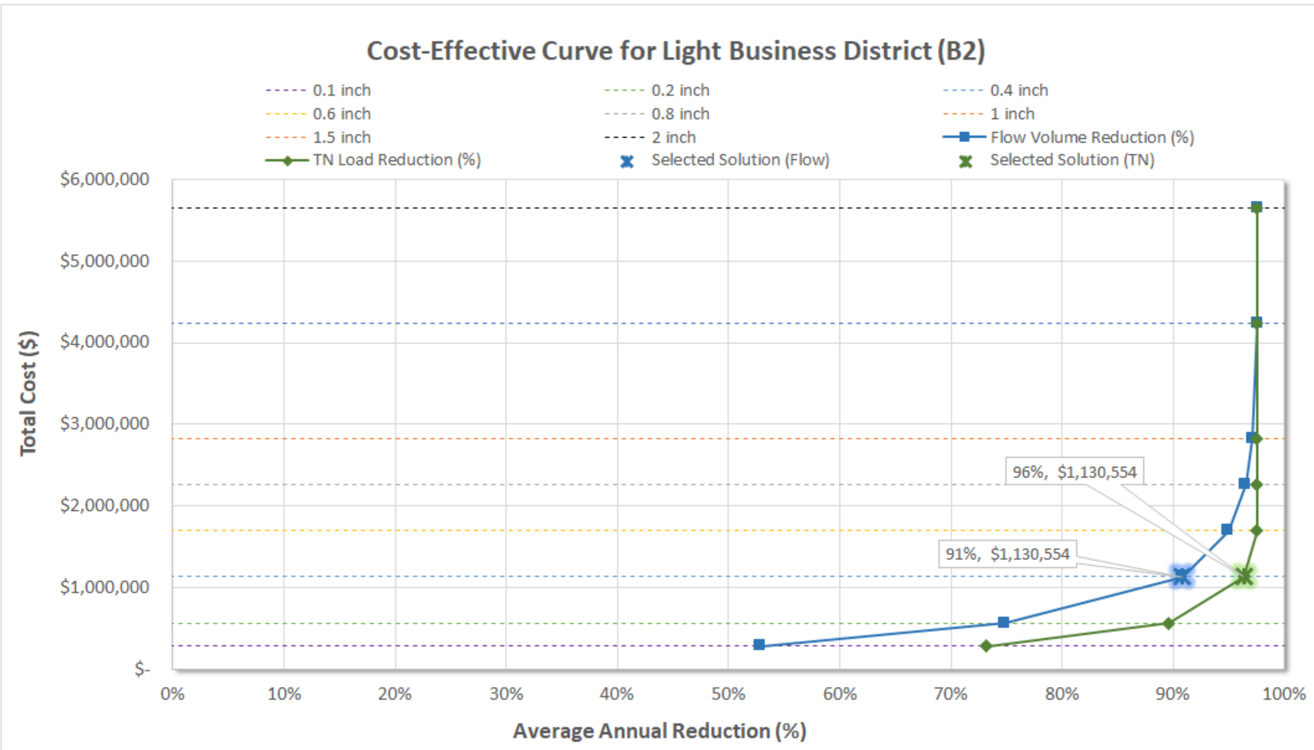

Figure 9. Cost effectiveness curves for incremental sizing of GI SCM opportunities in the B2 Light Business District Zone of Tisbury, MA.

Table 12. Infiltration GI SCM Solution (0.4 inch) for the B1 Business District of Tisbury, MA

Land Use Group	SCM Type	HSG	Infiltration GI SCM Solution (0.4 inch) for Light Business District (B2) in Tisbury				
			IC Disconnected (acres)	Storage Capacity (gallons)	Flow Volume Captured (gallons/yr)	TN Load Removed (lbs/yr)	SCM Cost ($)
Forest	Infiltration Trench (Rooftop disconnected)	A	0.066	720	62,586	0.521	$2,406
		B	0.005	55	4,062	0.039	$184
		C	-	-	-	-	-
	Infiltration Basin (Other IC disconnected)	A	1.980	21,509	1,884,859	15.712	$35,884
		B	0.152	1,651	120,495	1.157	$2,754
		C	-	-	-	-	-
Agriculture	Infiltration Trench (Rooftop disconnected)	A	-	-	-	-	-
		B	-	-	-	-	-
		C	-	-	-	-	-
	Infiltration Basin (Other IC disconnected)	A	-	-	-	-	-
		B	-	-	-	-	-
		C	-	-	-	-	-
Commercial	Infiltration Trench (Rooftop disconnected)	A	6.020	65,385	5,680,607	68.166	$218,344
		B	0.097	1,054	77,447	1.065	$3,520
		C	-	-	-	-	-
	Infiltration Basin (Other IC disconnected)	A	27.418	297,812	26,097,210	313.647	$496,850
		B	0.442	4,802	350,501	4.853	$8,012
		C	-	-	-	-	-
Industrial	Infiltration Trench (Rooftop disconnected)	A	2.188	23,769	2,065,064	24.780	$79,374
		B	-	-	-	-	-
		C	-	-	-	-	-
	Infiltration Basin (Other IC disconnected)	A	12.662	137,528	12,051,494	144.840	$229,442
		B	-	-	-	-	-
		C	-	-	-	-	-
Low Density Residential	Infiltration Trench (Rooftop disconnected)	A	0.030	327	28,448	0.314	$1,094
		B	-	-	-	-	-
		C	-	-	-	-	-
	Infiltration Basin (Other IC disconnected)	A	0.228	2,472	216,616	2.395	$4,124
		B	-	-	-	-	-
		C	-	-	-	-	-
Medium Density Residential	Infiltration Trench (Rooftop disconnected)	A	0.109	1,181	102,600	1.133	$3,944
		B	-	-	-	-	-
		C	-	-	-	-	-
	Infiltration Basin (Other IC disconnected)	A	0.740	8,036	704,180	7.786	$13,406
		B	-	-	-	-	-
		C	-	-	-	-	-
High Density Residential	Infiltration Trench (Rooftop disconnected)	A	0.163	1,766	153,434	1.694	$5,898
		B	-	-	-	-	-
		C	-	-	-	-	-
	Infiltration Basin (Other IC disconnected)	A	0.316	3,433	300,817	3.326	$5,728
		B	-	-	-	-	-
		C	-	-	-	-	-

Land Use Group	SCM Type	HSG	Infiltration GI SCM Solution (0.4 inch) for Light Business District (B2) in Tisbury				
			IC Disconnected (acres)	Storage Capacity (gallons)	Flow Volume Captured (gallons/yr)	TN Load Removed (lbs/yr)	SCM Cost ($)
Highway	Infiltration Trench (Rooftop disconnected)	A	-	-	-	-	-
		B	-	-	-	-	-
		C	-	-	-	-	-
	Infiltration Basin (Other IC disconnected)	A	-	-	-	-	-
		B	-	-	-	-	-
		C	-	-	-	-	-
Open Land	Infiltration Trench (Rooftop disconnected)	A	0.044	475	41,273	0.344	$1,586
		B	-	-	-	-	-
		C	-	-	-	-	-
	Infiltration Basin (Other IC disconnected)	A	0.994	10,792	945,727	7.884	$18,006
		B	-	-	-	-	-
		C	-	-	-	-	-
Total	**Infiltration Trench (Rooftop disconnected)**	**A**	**8.620**	**93,625**	**8,134,013**	**96.952**	**$312,644**
		B	**0.102**	**1,110**	**81,509**	**1.104**	**$3,706**
		C	**-**	**-**	**-**	**-**	**-**
	Infiltration Basin (Other IC disconnected)	**A**	**44.337**	**481,582**	**42,200,903**	**495.591**	**$803,440**
		B	**0.594**	**6,453**	**470,995**	**6.010**	**$10,766**
		C	**-**	**-**	**-**	**-**	**-**

3.4 LHP Lagoon Harbor Park

Figure 10 presents the HRUs for the Lagoon Harbor Park Zone. The majority of land in the district is pervious surfaces, with 25% of the area consisting of rooftops and other impervious surfaces. The GIS analyses did not identify any opportunities of GI SCM implementation in the area (Figure 11) due to proximity to mapped wetlands (Table 1), these areas present regulatory and physical barriers that limit the feasibility of infiltration-based opportunities. Given the lack of GI SCM implementation in the Lagoon Harbor Park zone, no cost effectiveness curves were generated. The analysis was based on desktop review of geospatial data, on-the-ground field assessment may help identify opportunities missed in this assessment.

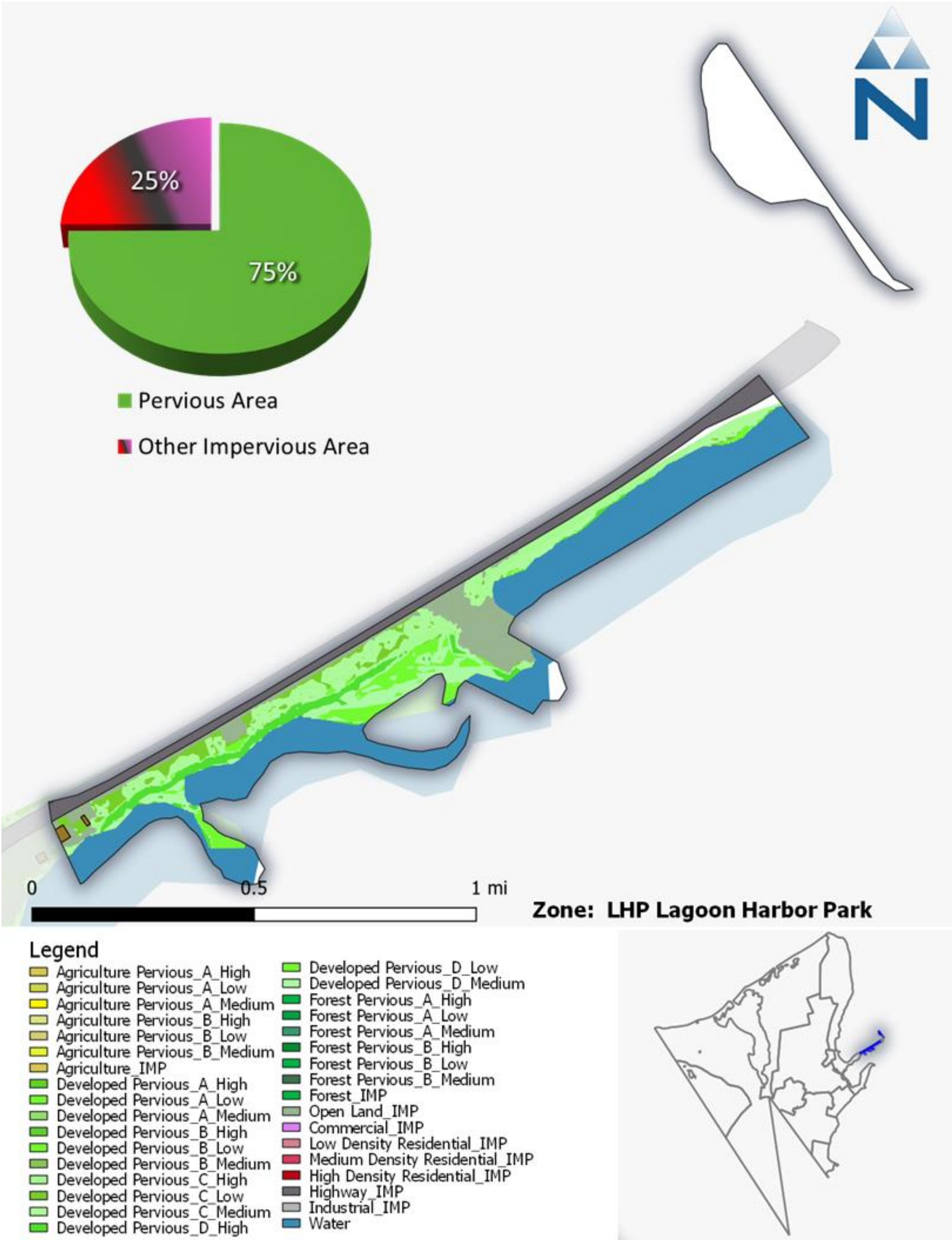

Figure 10. HRU distribution in the Lagoon Harbor Park Zone of Tisbury, MA.

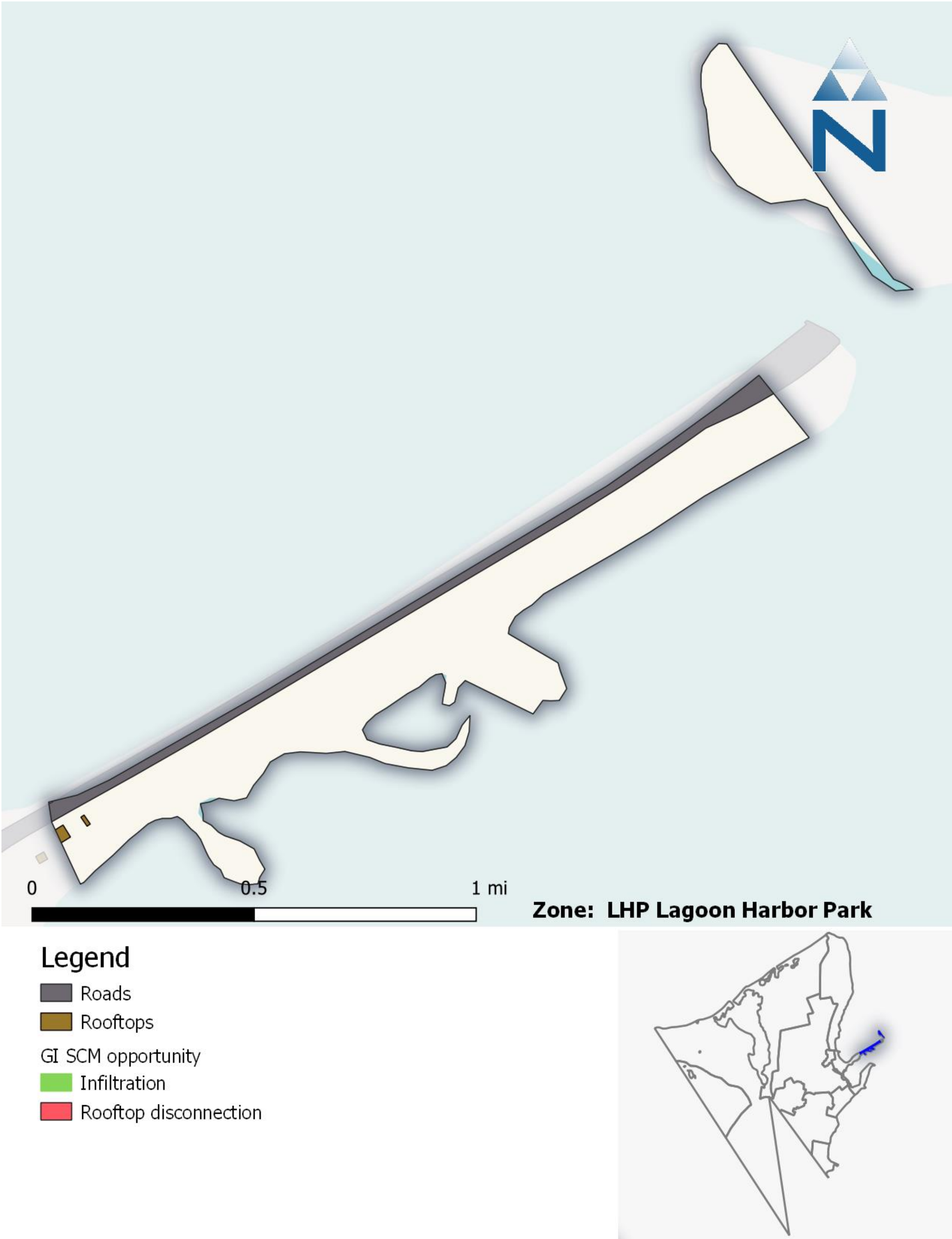

Figure 11. GI SCM opportunities in the Lagoon Harbor Park Zone of Tisbury, MA.

3.5 R3A Residential District

Figure 12 presents the HRUs for the R3A Residential District Zone. The majority of land in the district is pervious surfaces, with only 6% of the area consisting of rooftops and other impervious surfaces. Figure 13 presents the GI SCM opportunities in the area. A 0.4 inch design criteria achieved a 57% reduction in flow volume and a 54% reduction in TN loading (Figure 14). The reductions were achieved at a cost of $1,608,886. Interestingly, the TN and flow curves cross each other at a relatively small design interval (approximately 0.3 inches). The graph suggests that managing TN in the R3A residential zone through GI SCM implementation to treat impervious surfaces becomes exceedingly expensive with little improvement to load reductions. This is likely because the zone is dominated by pervious surfaces, including agriculture, the TN loading from which is not treated in this analysis by the GIS SCM opportunities.

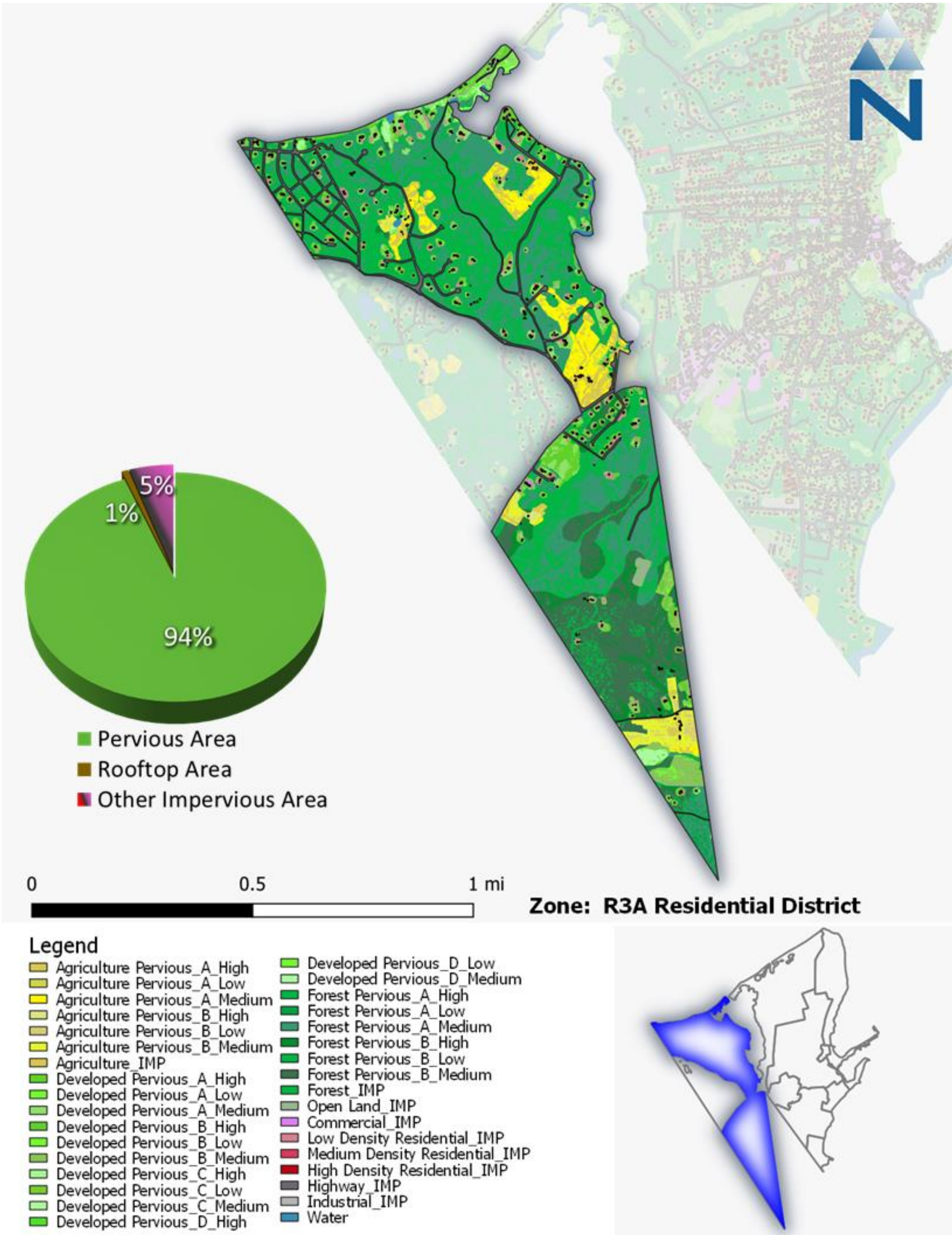

Figure 12. HRU distribution in the R3A Residential District Zone of Tisbury, MA.

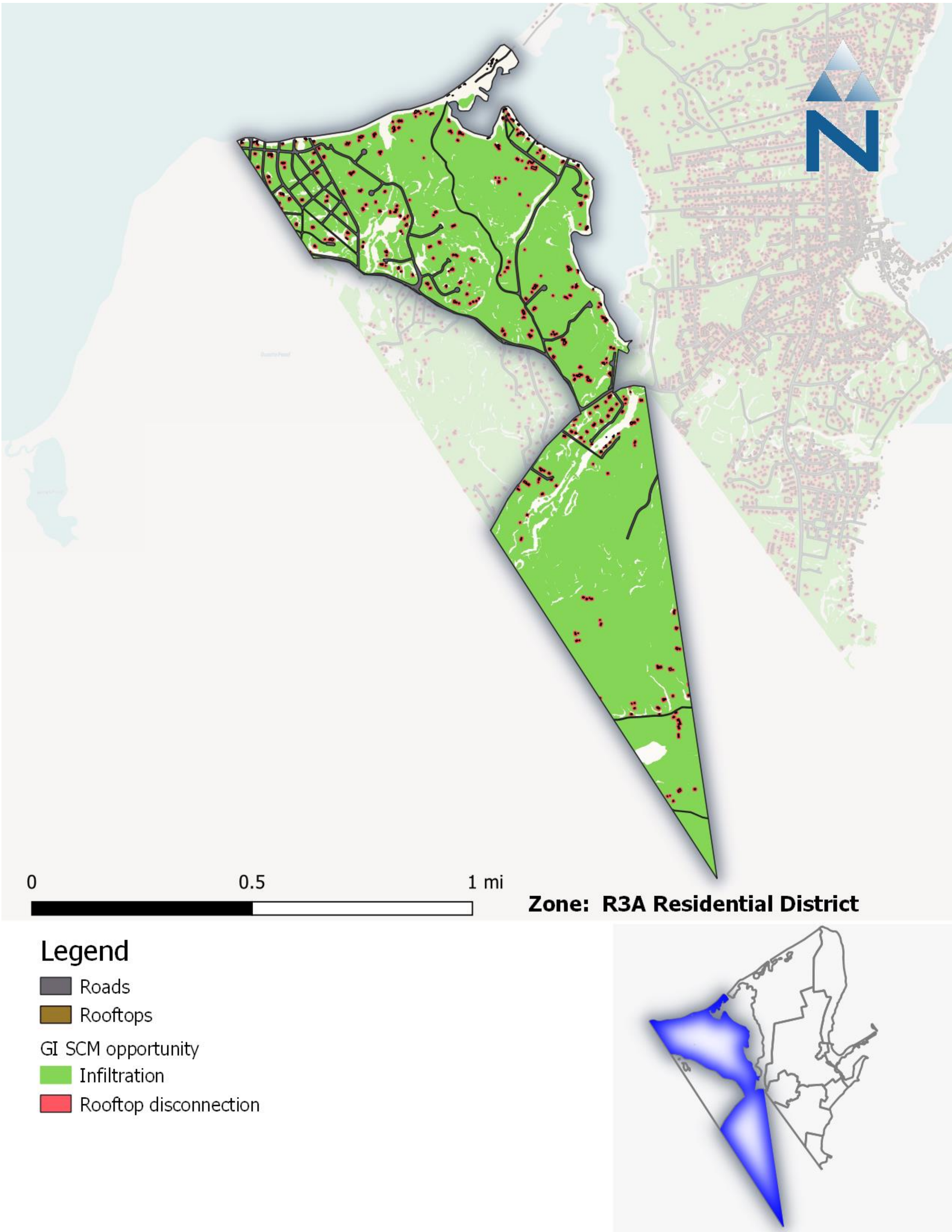

Figure 13. GI SCM opportunities in the R3A Residential District Zone of Tisbury, MA.

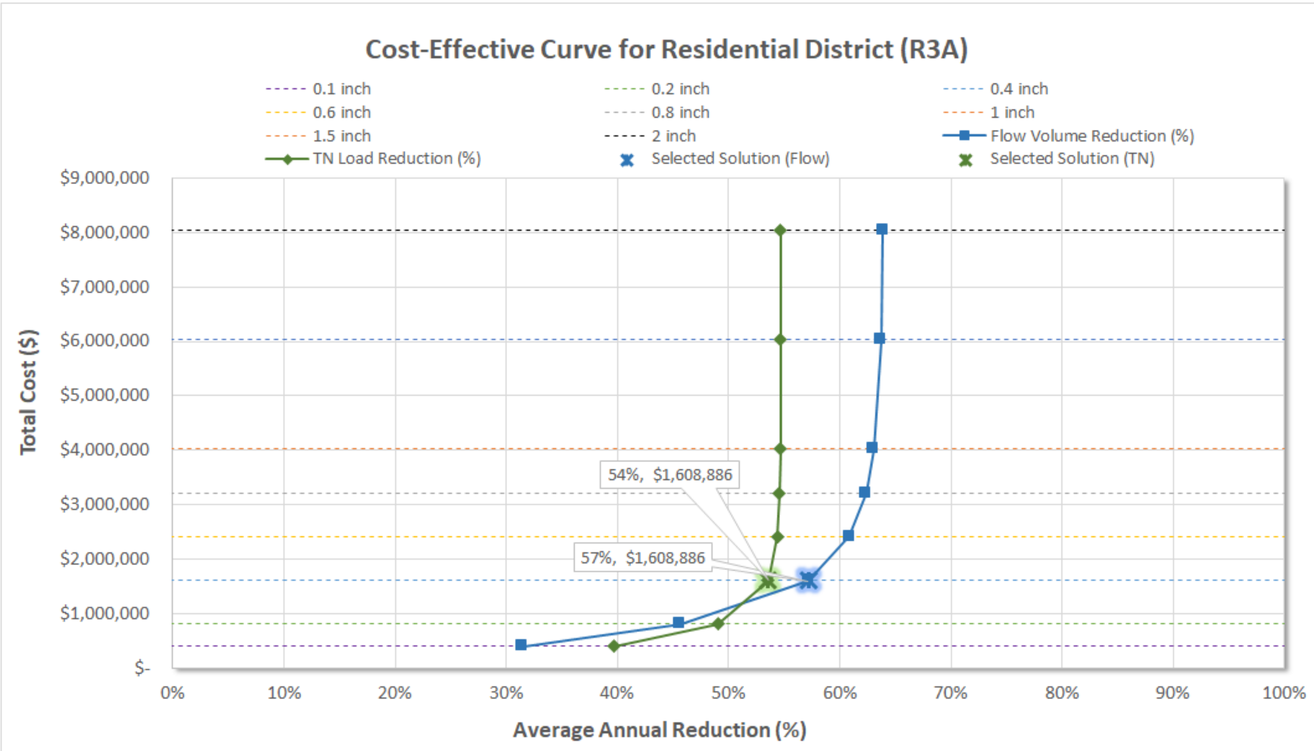

Figure 14. Cost effectiveness curves for incremental sizing of GI SCM opportunities in the R3A Residential District Zone of Tisbury, MA.

Table 13. Infiltration GI SCM Solution (0.4 inch) for the R3A Residential District of Tisbury, MA

Land Use Group	SCM Type	HSG	Infiltration GI SCM Solution (0.4 inch) for Residential District (R3A) in Tisbury				
			IC Disconnected (acres)	Storage Capacity (gallons)	Flow Volume Captured (gallons/yr)	TN Load Removed (lbs/yr)	SCM Cost ($)
Forest	Infiltration Trench (Rooftop disconnected)	A	0.752	8,168	709,608	5.906	$27,274
		B	0.226	2,450	179,990	1.717	$8,182
		C	-	-	-	-	-
	Infiltration Basin (Other IC disconnected)	A	32.876	357,096	31,292,214	260.857	$595,756
		B	9.862	107,118	7,818,943	75.088	$178,710
		C	-	-	-	-	-
Agriculture	Infiltration Trench (Rooftop disconnected)	A	0.697	7,569	657,580	5.473	$25,276
		B	0.241	2,622	192,633	1.838	$8,756
		C	-	-	-	-	-
	Infiltration Basin (Other IC disconnected)	A	4.343	47,170	4,133,460	34.457	$78,694
		B	1.505	16,342	1,192,827	11.455	$27,264
		C	-	-	-	-	-
Commercial	Infiltration Trench (Rooftop disconnected)	A	0.125	1,359	118,047	1.417	$4,538
		B	0.031	340	24,993	0.344	$1,136
		C	-	-	-	-	-
	Infiltration Basin (Other IC disconnected)	A	0.360	3,911	342,716	4.119	$6,524
		B	0.090	979	71,480	0.990	$1,634
		C	-	-	-	-	-
Industrial	Infiltration Trench (Rooftop disconnected)	A	-	-	-	-	-
		B	-	-	-	-	-
		C	-	-	-	-	-
	Infiltration Basin (Other IC disconnected)	A	-	-	-	-	-
		B	-	-	-	-	-
		C	-	-	-	-	-
Low Density Residential	Infiltration Trench (Rooftop disconnected)	A	6.768	73,517	6,387,061	70.511	$245,498
		B	1.337	14,524	1,066,935	13.503	$48,498
		C	-	-	-	-	-
	Infiltration Basin (Other IC disconnected)	A	11.037	119,876	10,504,730	116.149	$199,994
		B	2.180	23,682	1,728,636	22.019	$39,510
		C	-	-	-	-	-
Medium Density Residential	Infiltration Trench (Rooftop disconnected)	A	-	-	-	-	-
		B	-	-	-	-	-
		C	-	-	-	-	-
	Infiltration Basin (Other IC disconnected)	A	-	-	-	-	-
		B	-	-	-	-	-
		C	-	-	-	-	-
High Density Residential	Infiltration Trench (Rooftop disconnected)	A	-	-	-	-	-
		B	-	-	-	-	-
		C	-	-	-	-	-
	Infiltration Basin (Other IC disconnected)	A	-	-	-	-	-
		B	-	-	-	-	-
		C	-	-	-	-	-

Land Use Group	SCM Type	HSG	Infiltration GI SCM Solution (0.4 inch) for Residential District (R3A) in Tisbury				
			IC Disconnected (acres)	Storage Capacity (gallons)	Flow Volume Captured (gallons/yr)	TN Load Removed (lbs/yr)	SCM Cost ($)
Highway	Infiltration Trench (Rooftop disconnected)	A	-	-	-	-	-
		B	-	-	-	-	-
		C	-	-	-	-	-
	Infiltration Basin (Other IC disconnected)	A	-	-	-	-	-
		B	-	-	-	-	-
		C	-	-	-	-	-
Open Land	Infiltration Trench (Rooftop disconnected)	A	0.115	1,251	108,673	0.905	$4,178
		B	0.165	1,787	131,308	1.253	$5,968
		C	-	-	-	-	-
	Infiltration Basin (Other IC disconnected)	A	2.306	25,047	2,194,856	18.297	$41,786
		B	3.295	35,791	2,612,509	25.089	$59,712
		C	-	-	-	-	-
Total	**Infiltration Trench (Rooftop disconnected)**	**A**	**8.457**	**91,863**	**7,980,969**	**84.212**	**$306,762**
		B	**2.000**	**21,723**	**1,595,859**	**18.656**	**$72,542**
		C	**-**	**-**	**-**	**-**	**-**
	Infiltration Basin (Other IC disconnected)	**A**	**50.922**	**553,100**	**48,467,977**	**433.878**	**$922,756**
		B	**16.932**	**183,912**	**13,424,395**	**134.640**	**$306,828**
		C	**-**	**-**	**-**	**-**	**-**

3.6 R10 Residential District

Figure 15 presents the HRUs for the R10 Residential District Zone. The majority of land in the district is pervious surfaces, with 28% of the area consisting of rooftops and other impervious surfaces. Figure 16 presents the GI SCM opportunities in the area. A 0.4 inch design criteria achieved an 89% reduction in flow volume and a 93% reduction in TN loading (Figure 17). The reductions were achieved at a cost of $4,169,444.

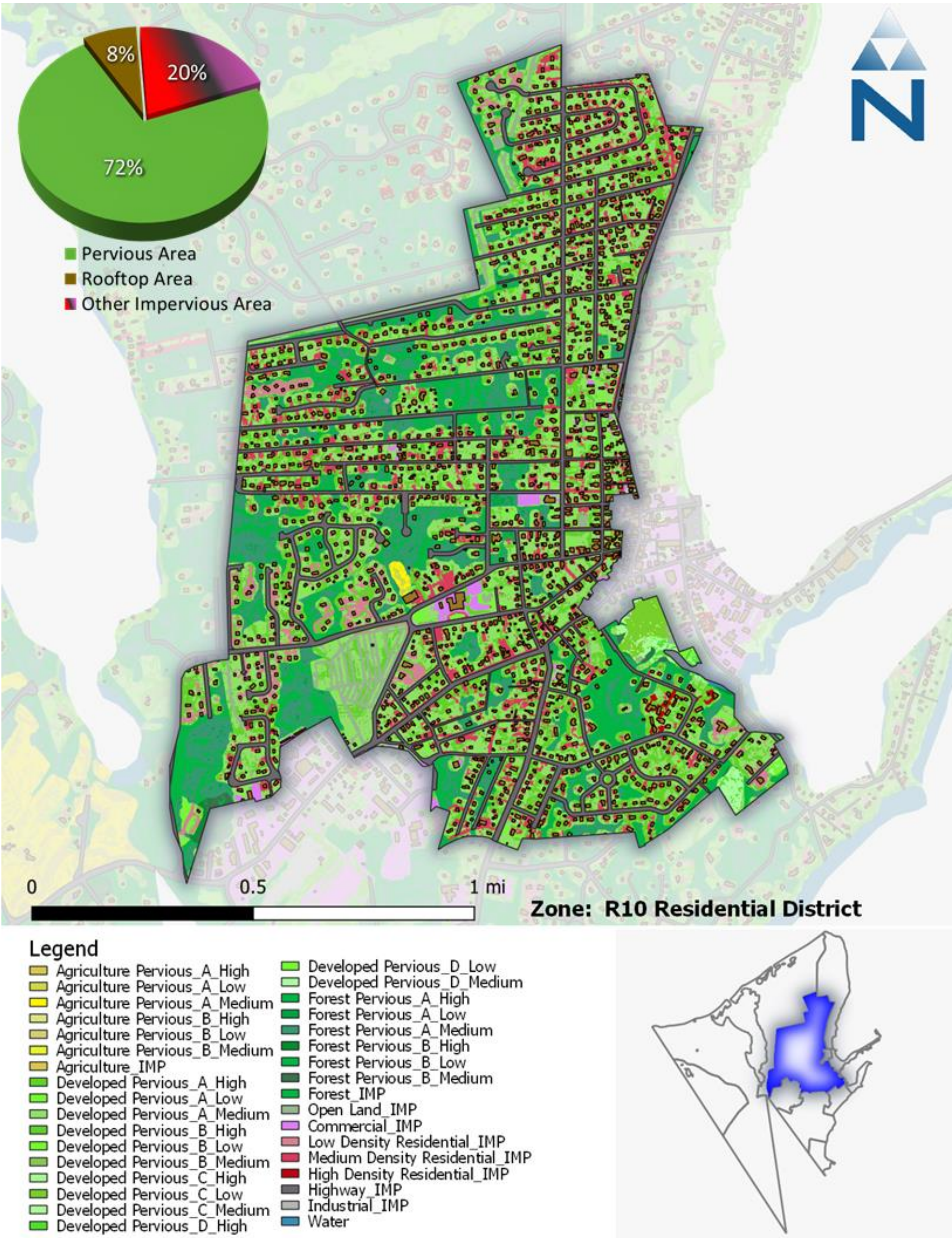

Figure 15. HRU distribution in the R10 Residential District Zone of Tisbury, MA.

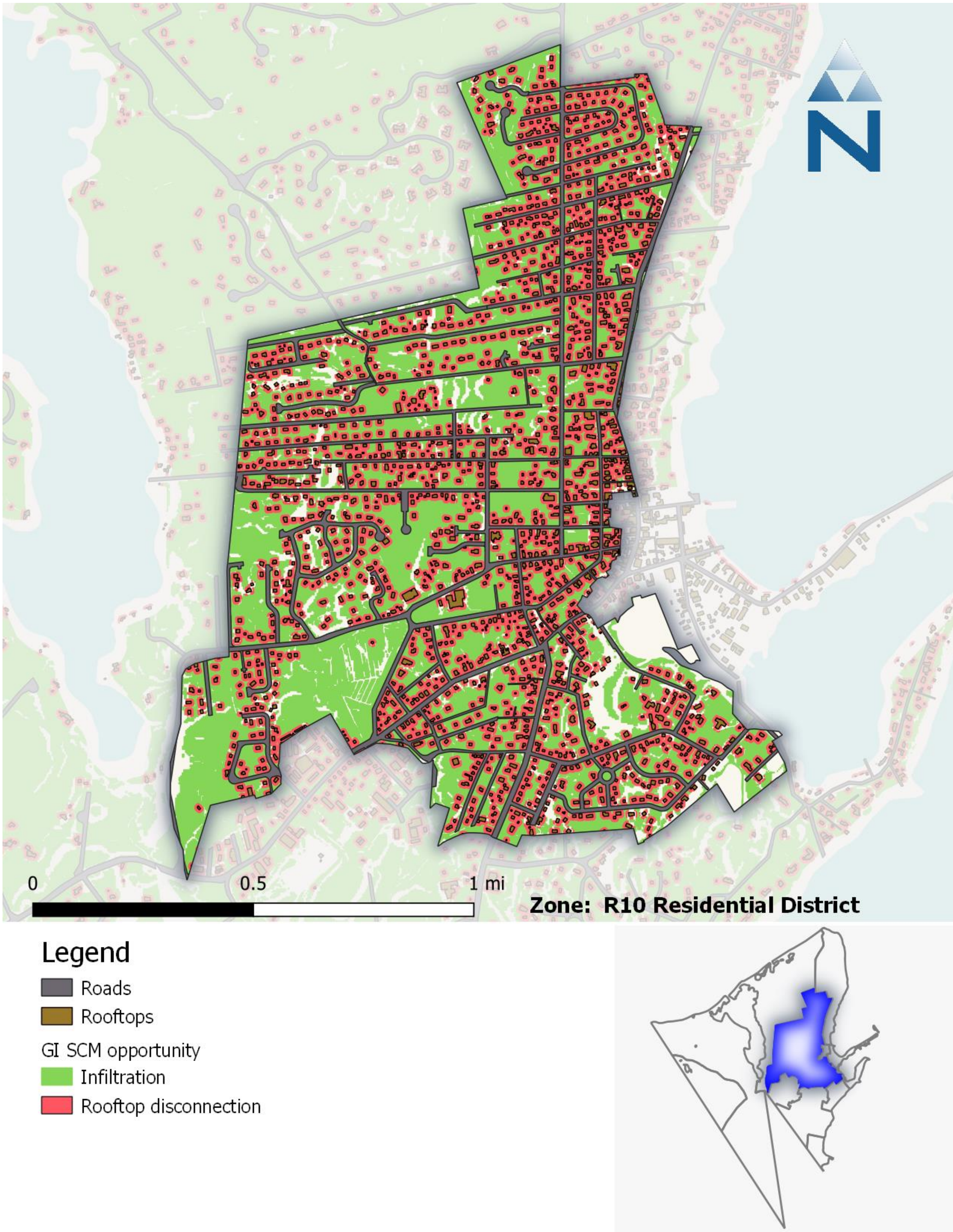

Figure 16. GI SCM opportunities in the R10 Residential District Zone of Tisbury, MA.

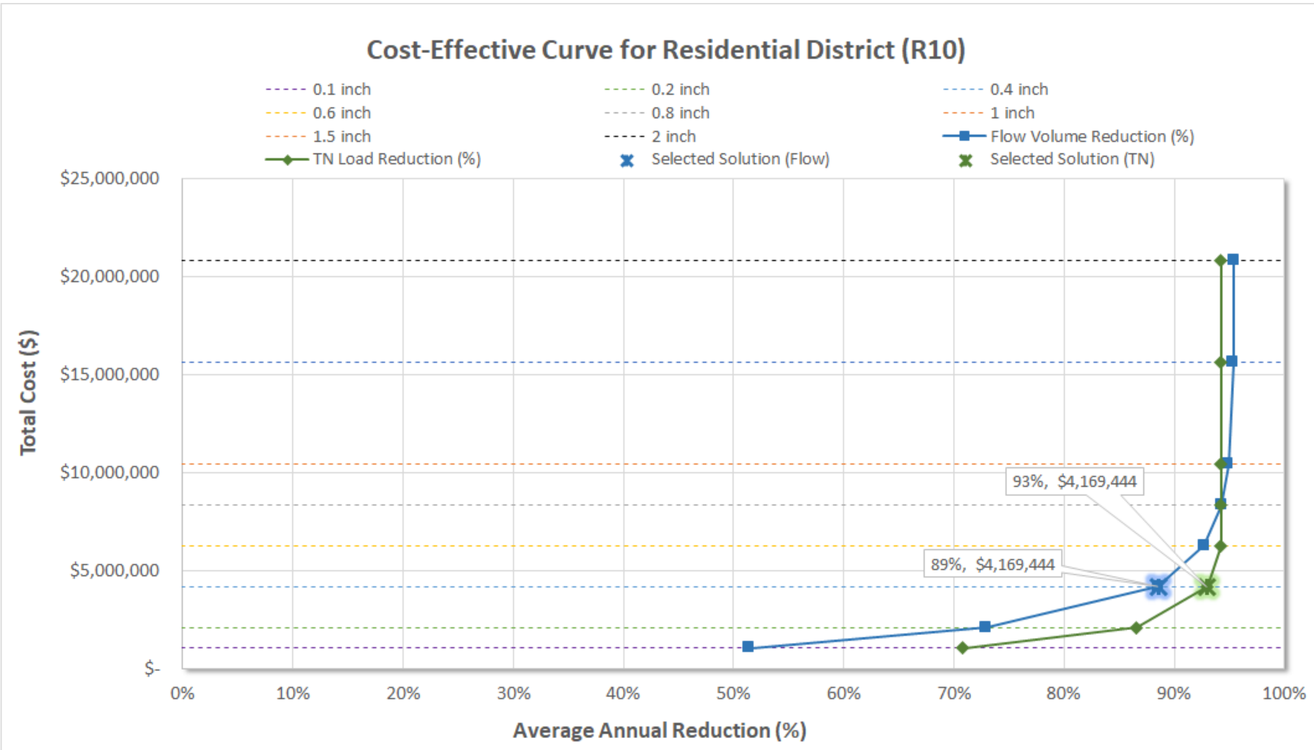

Figure 17. Cost effectiveness curves for incremental sizing of GI SCM opportunities in the R10 Residential District Zone of Tisbury, MA.

Table 14. Infiltration GI SCM Solution (0.4 inch) for the R10 Residential District of Tisbury, MA

Land Use Group	SCM Type	HSG	Infiltration GI SCM Solution (0.4 inch) for Residential District (R10) in Tisbury				
			IC Disconnected (acres)	Storage Capacity (gallons)	Flow Volume Captured (gallons/yr)	TN Load Removed (lbs/yr)	SCM Cost ($)
Forest	Infiltration Trench (Rooftop disconnected)	A	1.669	18,124	1,574,573	13.106	$60,522
		B	0.016	173	12,739	0.122	$580
		C	0.004	40	2,551	0.027	$134
	Infiltration Basin (Other IC disconnected)	A	9.901	107,543	9,423,987	78.560	$179,418
		B	0.095	1,029	75,111	0.721	$1,716
		C	0.022	237	14,558	0.161	$394
Agriculture	Infiltration Trench (Rooftop disconnected)	A	0.006	70	6,063	0.050	$234
		B	-	-	-	-	-
		C	-	-	-	-	-
	Infiltration Basin (Other IC disconnected)	A	-	-	-	-	-
		B	-	-	-	-	-
		C	-	-	-	-	-
Commercial	Infiltration Trench (Rooftop disconnected)	A	2.197	23,862	2,073,142	24.877	$79,684
		B	-	-	-	-	-
		C	0.029	320	20,498	0.314	$1,070
	Infiltration Basin (Other IC disconnected)	A	6.212	67,474	5,912,736	71.062	$112,570
		B	-	-	-	-	-
		C	0.083	906	55,751	0.887	$1,512
Industrial	Infiltration Trench (Rooftop disconnected)	A	0.031	333	28,915	0.347	$1,112
		B	-	-	-	-	-
		C	-	-	-	-	-
	Infiltration Basin (Other IC disconnected)	A	0.497	5,395	472,746	5.682	$9,000
		B	-	-	-	-	-
		C	-	-	-	-	-
Low Density Residential	Infiltration Trench (Rooftop disconnected)	A	5.491	59,641	5,181,553	57.203	$199,162
		B	0.029	311	22,868	0.289	$1,040
		C	-	-	-	-	-
	Infiltration Basin (Other IC disconnected)	A	18.402	199,880	17,515,429	193.664	$333,466
		B	0.096	1,043	76,149	0.970	$1,740
		C	-	-	-	-	-
Medium Density Residential	Infiltration Trench (Rooftop disconnected)	A	38.645	419,758	36,468,186	402.597	$1,401,714
		B	-	-	-	-	-
		C	0.000	2	111	0.002	$6
	Infiltration Basin (Other IC disconnected)	A	83.954	911,884	79,908,082	883.527	$1,521,326
		B	-	-	-	-	-
		C	0.000	4	232	0.003	$6
High Density Residential	Infiltration Trench (Rooftop disconnected)	A	0.924	10,038	872,102	9.628	$33,520
		B	-	-	-	-	-
		C	-	-	-	-	-
	Infiltration Basin (Other IC disconnected)	A	1.310	14,228	1,246,779	13.785	$23,736
		B	-	-	-	-	-
		C	-	-	-	-	-

Land Use Group	SCM Type	HSG	Infiltration GI SCM Solution (0.4 inch) for Residential District (R10) in Tisbury				
			IC Disconnected (acres)	Storage Capacity (gallons)	Flow Volume Captured (gallons/yr)	TN Load Removed (lbs/yr)	SCM Cost ($)
Highway	Infiltration Trench (Rooftop disconnected)	A	-	-	-	-	$2,382
		B	-	-	-	-	-
		C	-	-	-	-	$558
	Infiltration Basin (Other IC disconnected)	A	-	-	-	-	$164,380
		B	-	-	-	-	-
		C	-	-	-	-	$38,464
Open Land	Infiltration Trench (Rooftop disconnected)	A	0.066	713	61,981	0.516	$2,382
		B	-	-	-	-	-
		C	0.015	167	10,681	0.113	$558
	Infiltration Basin (Other IC disconnected)	A	9.071	98,530	8,634,143	71.976	$164,380
		B	-	-	-	-	-
		C	2.123	23,055	1,418,955	15.651	$38,464
Total	**Infiltration Trench (Rooftop disconnected)**	**A**	**49.029**	**532,539**	**46,266,515**	**508.323**	**$1,778,330**
		B	**0.045**	**485**	**35,607**	**0.411**	**$1,618**
		C	**0.049**	**529**	**33,841**	**0.455**	**$1,766**
	Infiltration Basin (Other IC disconnected)	**A**	**129.347**	**1,404,934**	**123,113,903**	**1,318.256**	**$2,343,898**
		B	**0.191**	**2,072**	**151,259**	**1.691**	**$3,458**
		C	**2.228**	**24,201**	**1,489,497**	**16.701**	**$40,376**

3.7 R20 Residential District

Figure 18 presents the HRUs for the R20 Residential District Zone. The majority of land in the district is pervious surfaces, with 22% of the area consisting of rooftops and other impervious surfaces. Figure 19 presents the GI SCM opportunities in the area. A 0.4 inch design criteria achieved an 87% reduction in flow volume and a 92% reduction in TN loading (Figure 20). The reductions were achieved at a cost of $1,599,198.

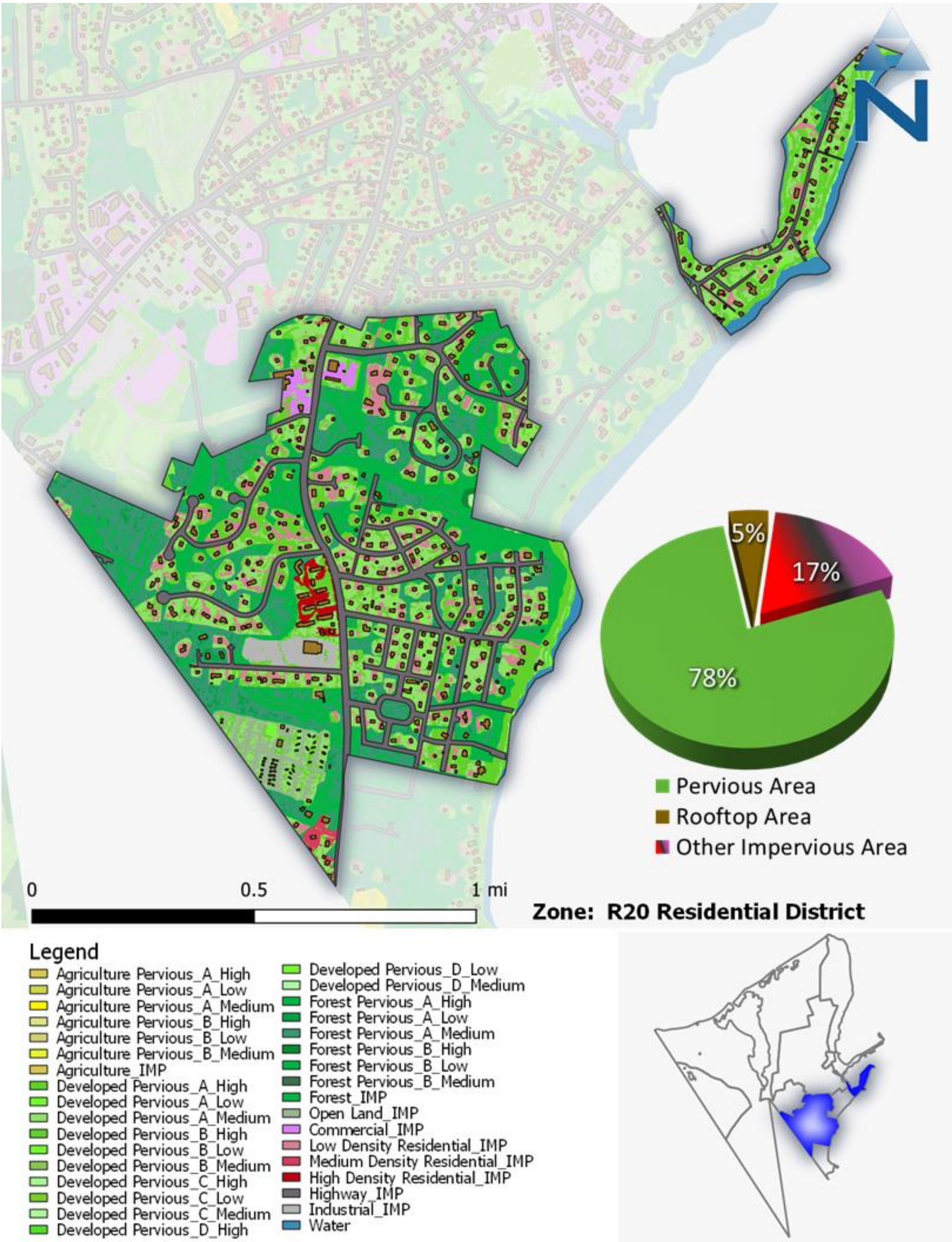

Figure 18. HRU distribution in the R20 Residential District Zone of Tisbury, MA.

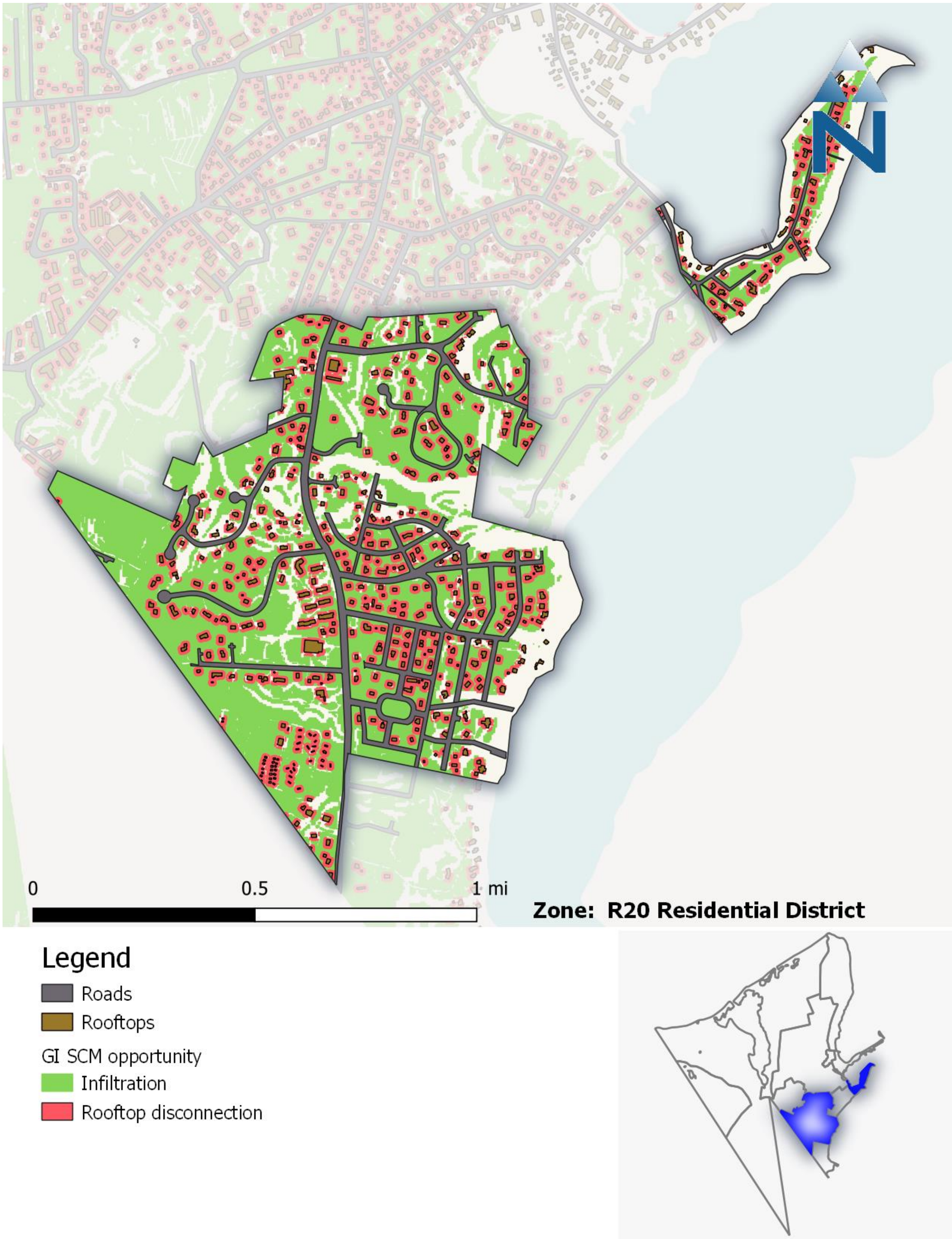

Figure 19. GI SCM opportunities in the R20 Residential District Zone of Tisbury, MA.

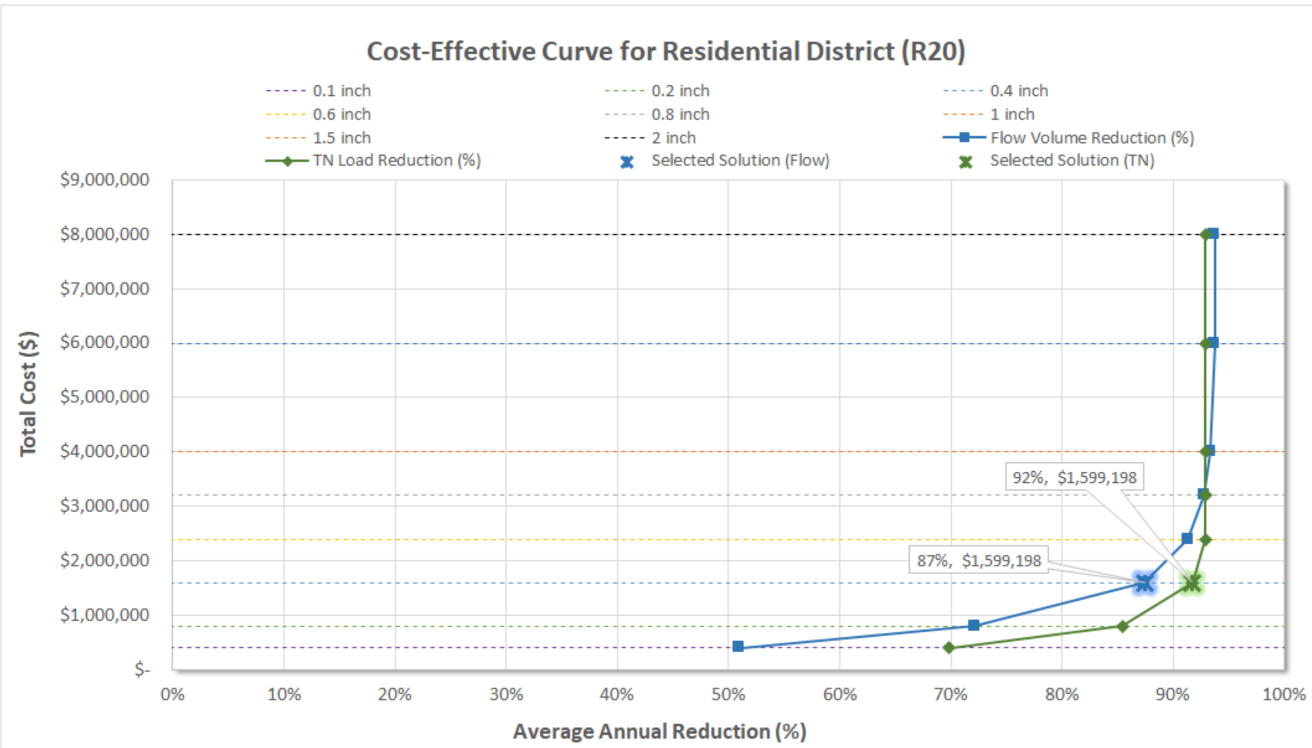

Figure 20. Cost effectiveness curves for incremental sizing of GI SCM opportunities in the R20 Residential District Zone of Tisbury, MA.

Table 15. Infiltration GI SCM Solution (0.4 inch) for the R20 Residential District of Tisbury, MA

Land Use Group	SCM Type	HSG	Infiltration GI SCM Solution (0.4 inch) for Residential District (R20) in Tisbury				
			IC Disconnected (acres)	Storage Capacity (gallons)	Flow Volume Captured (gallons/yr)	TN Load Removed (lbs/yr)	SCM Cost ($)
Forest	Infiltration Trench (Rooftop disconnected)	A	0.810	8,795	764,139	6.360	$29,370
		B	-	-	-	-	-
		C	-	-	-	-	-
	Infiltration Basin (Other IC disconnected)	A	12.024	130,606	11,444,921	95.407	$217,894
		B	-	-	-	-	-
		C	-	-	-	-	-
Agriculture	Infiltration Trench (Rooftop disconnected)	A	-	-	-	-	-
		B	-	-	-	-	-
		C	-	-	-	-	-
	Infiltration Basin (Other IC disconnected)	A	-	-	-	-	-
		B	-	-	-	-	-
		C	-	-	-	-	-
Commercial	Infiltration Trench (Rooftop disconnected)	A	0.613	6,654	578,059	6.937	$22,218
		B	-	-	-	-	-
		C	-	-	-	-	-
	Infiltration Basin (Other IC disconnected)	A	2.280	24,762	2,169,927	26.079	$41,312
		B	-	-	-	-	-
		C	-	-	-	-	-
Industrial	Infiltration Trench (Rooftop disconnected)	A	0.386	4,198	364,697	4.376	$14,018
		B	-	-	-	-	-
		C	-	-	-	-	-
	Infiltration Basin (Other IC disconnected)	A	4.521	49,101	4,302,694	51.712	$81,916
		B	-	-	-	-	-
		C	-	-	-	-	-
Low Density Residential	Infiltration Trench (Rooftop disconnected)	A	12.053	130,920	11,374,174	125.567	$437,184
		B	-	-	-	-	-
		C	-	-	-	-	-
	Infiltration Basin (Other IC disconnected)	A	30.302	329,129	28,841,502	318.894	$549,098
		B	-	-	-	-	-
		C	-	-	-	-	-
Medium Density Residential	Infiltration Trench (Rooftop disconnected)	A	0.305	3,312	287,747	3.177	$11,060
		B	-	-	-	-	-
		C	-	-	-	-	-
	Infiltration Basin (Other IC disconnected)	A	1.119	12,158	1,065,442	11.780	$20,284
		B	-	-	-	-	-
		C	-	-	-	-	-
High Density Residential	Infiltration Trench (Rooftop disconnected)	A	0.759	8,245	716,337	7.908	$27,534
		B	-	-	-	-	-
		C	-	-	-	-	-
	Infiltration Basin (Other IC disconnected)	A	2.299	24,969	2,188,038	24.193	$41,656
		B	-	-	-	-	-
		C	-	-	-	-	-

Land Use Group	SCM Type	HSG	Infiltration GI SCM Solution (0.4 inch) for Residential District (R20) in Tisbury				
			IC Disconnected (acres)	Storage Capacity (gallons)	Flow Volume Captured (gallons/yr)	TN Load Removed (lbs/yr)	SCM Cost ($)
Highway	Infiltration Trench (Rooftop disconnected)	A	-	-	-	-	-
		B	-	-	-	-	-
		C	-	-	-	-	-
	Infiltration Basin (Other IC disconnected)	A	-	-	-	-	-
		B	-	-	-	-	-
		C	-	-	-	-	-
Open Land	Infiltration Trench (Rooftop disconnected)	A	0.531	5,763	500,643	4.167	$19,244
		B	-	-	-	-	-
		C	-	-	-	-	-
	Infiltration Basin (Other IC disconnected)	A	4.768	51,793	4,538,596	37.834	$86,408
		B	-	-	-	-	-
		C	-	-	-	-	-
Total	**Infiltration Trench (Rooftop disconnected)**	**A**	**15.457**	**167,886**	**14,585,796**	**158.492**	**$560,628**
		B	**-**	**-**	**-**	**-**	**-**
		C	**-**	**-**	**-**	**-**	**-**
	Infiltration Basin (Other IC disconnected)	**A**	**57.313**	**622,519**	**54,551,120**	**565.899**	**$1,038,568**
		B	**-**	**-**	**-**	**-**	-
		C	**-**	**-**	**-**	**-**	-

3.8 R25 Residential District

Figure 21 presents the HRUs for the R25 Residential District Zone. The majority of land in the district is pervious surfaces, with 16% of the area consisting of rooftops and other impervious surfaces. Figure 22 presents the GI SCM opportunities in the area. A 0.4 inch design criteria achieved an 81% reduction in flow volume and an 84% reduction in TN loading (Figure 23). The reductions were achieved at a cost of $1,270,025.

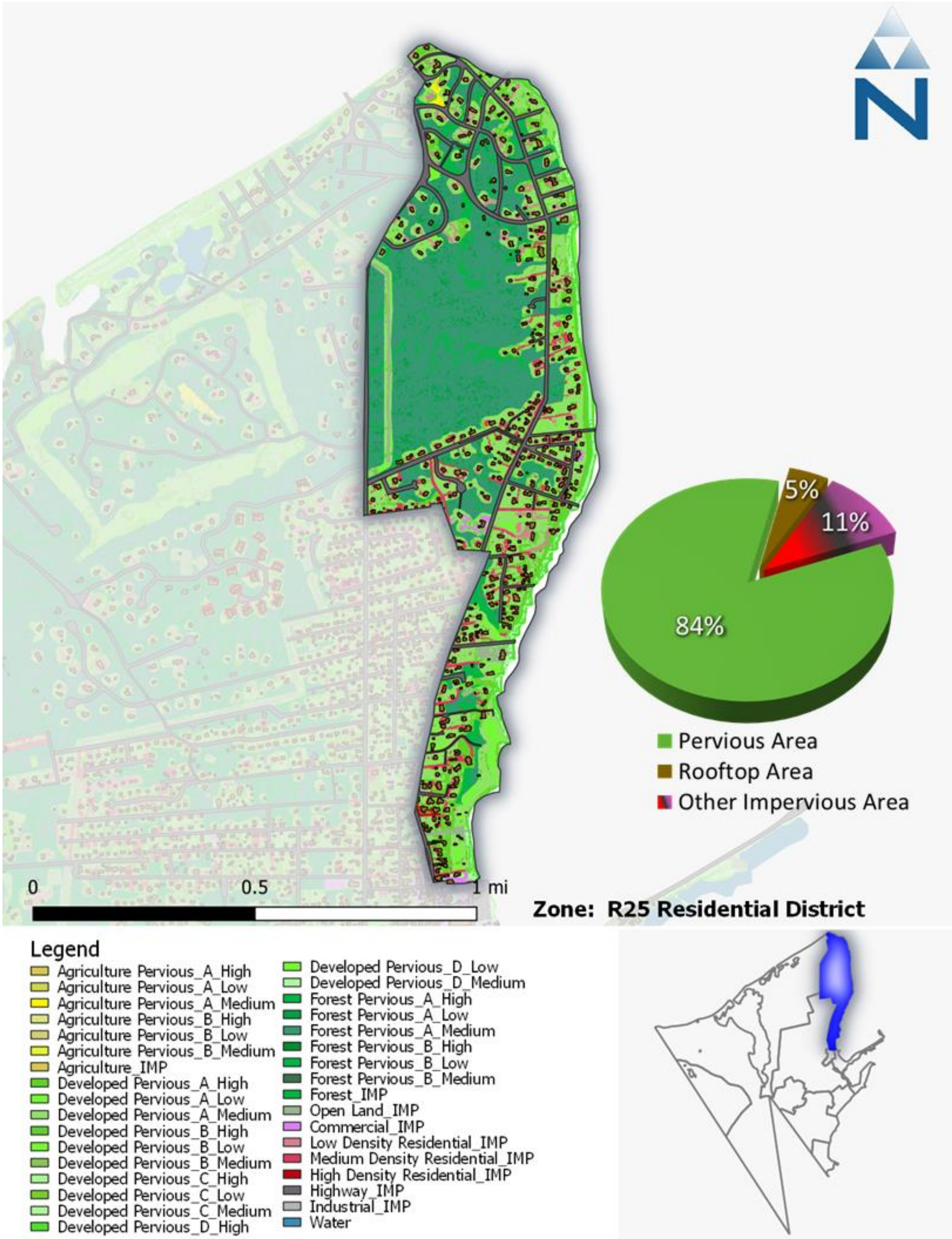

Figure 21. HRU distribution in the R25 Residential District Zone of Tisbury, MA.

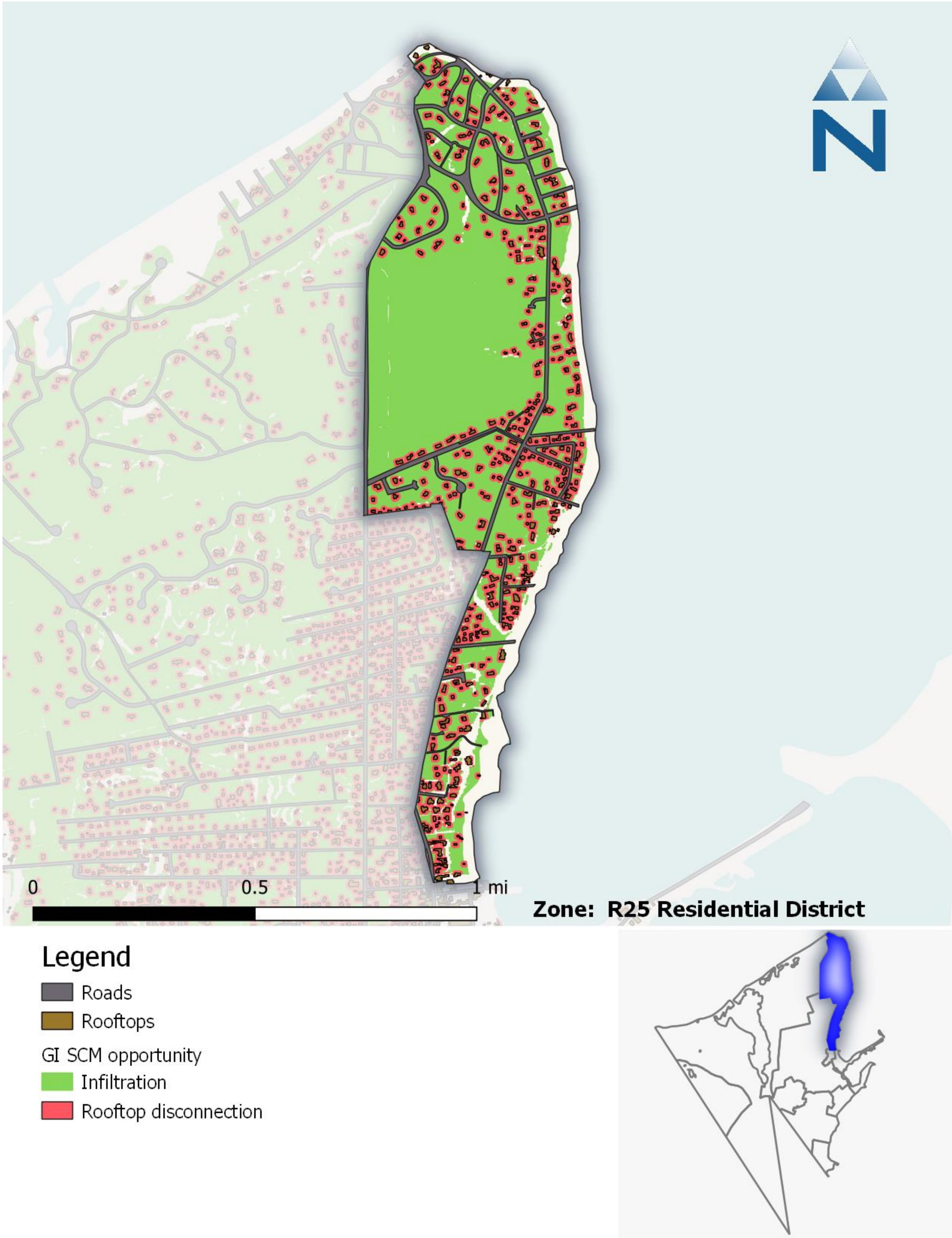

Figure 22. GI SCM opportunities in the R25 Residential District Zone of Tisbury, MA.

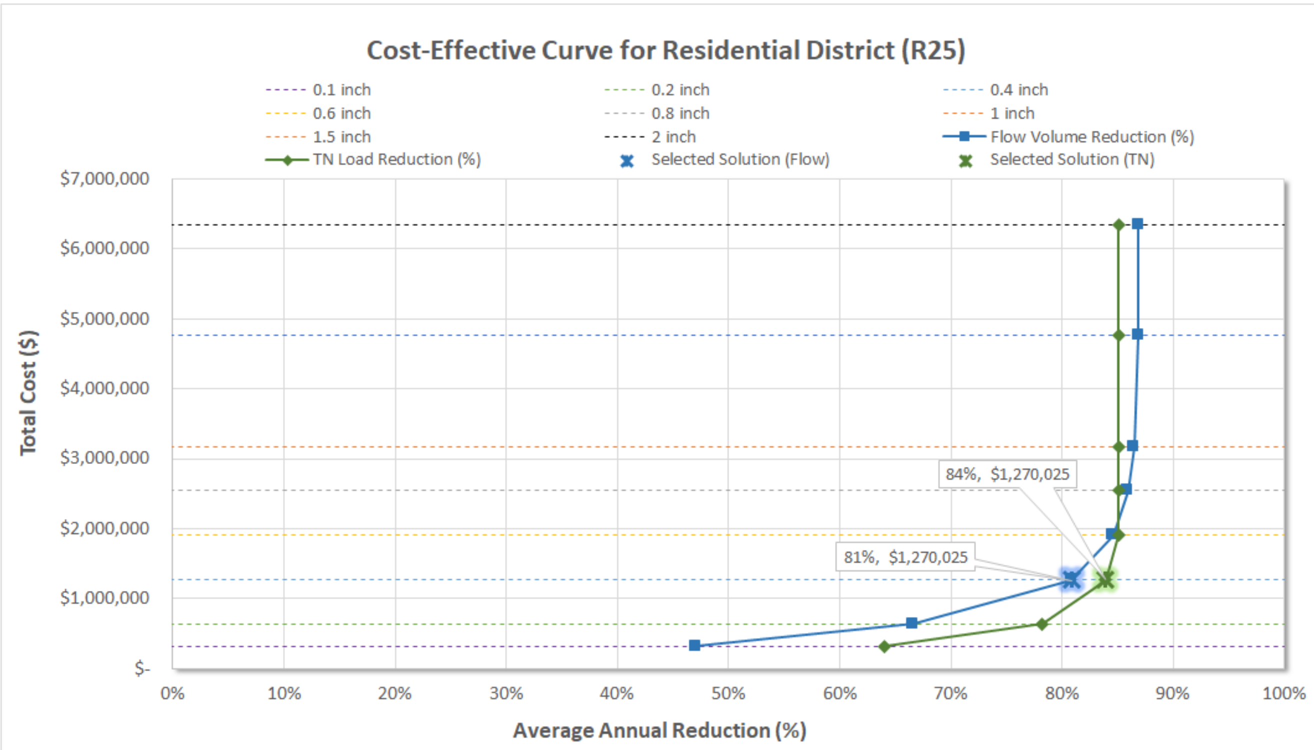

Figure 23. Cost effectiveness curves for incremental sizing of GI SCM opportunities in the R25 Residential District Zone of Tisbury, MA.

Table 16. Infiltration GI SCM Solution (0.4 inch) for the R50 Residential District of Tisbury, MA

Land Use Group	SCM Type	HSG	Infiltration GI SCM Solution (0.4 inch) for Residential District (R25) in Tisbury				
			IC Disconnected (acres)	Storage Capacity (gallons)	Flow Volume Captured (gallons/yr)	TN Load Removed (lbs/yr)	SCM Cost ($)
Forest	Infiltration Trench (Rooftop disconnected)	A	0.631	6,858	595,781	4.959	$22,900
		B	-	-	-	-	-
		C	-	-	-	-	-
	Infiltration Basin (Other IC disconnected)	A	7.361	79,951	7,006,048	58.404	$133,384
		B	-	-	-	-	-
		C	-	-	-	-	-
Agriculture	Infiltration Trench (Rooftop disconnected)	A	-	-	-	-	-
		B	-	-	-	-	-
		C	-	-	-	-	-
	Infiltration Basin (Other IC disconnected)	A	0.114	1,243	108,896	0.908	$2,074
		B	-	-	-	-	-
		C	-	-	-	-	-
Commercial	Infiltration Trench (Rooftop disconnected)	A	0.504	5,470	475,242	5.703	$18,266
		B	-	-	-	-	-
		C	0.070	765	48,934	0.748	$2,554
	Infiltration Basin (Other IC disconnected)	A	1.228	13,340	1,168,965	14.049	$22,256
		B	-	-	-	-	-
		C	0.172	1,865	114,783	1.825	$1,556
Industrial	Infiltration Trench (Rooftop disconnected)	A	-	-	-	-	-
		B	-	-	-	-	-
		C	-	-	-	-	-
	Infiltration Basin (Other IC disconnected)	A	-	-	-	-	-
		B	-	-	-	-	-
		C	-	-	-	-	-
Low Density Residential	Infiltration Trench (Rooftop disconnected)	A	4.065	44,157	3,836,318	42.352	$147,456
		B	-	-	-	-	-
		C	-	-	-	-	-
	Infiltration Basin (Other IC disconnected)	A	7.355	79,889	7,000,638	77.405	$133,282
		B	-	-	-	-	-
		C	-	-	-	-	-
Medium Density Residential	Infiltration Trench (Rooftop disconnected)	A	10.635	115,511	10,035,527	110.789	$385,732
		B	-	-	-	-	-
		C	0.000	2	132	0.002	$1,556
	Infiltration Basin (Other IC disconnected)	A	17.123	185,986	16,297,919	180.203	$310,288
		B	-	-	-	-	-
		C	0.000	3	205	0.003	$1,556
High Density Residential	Infiltration Trench (Rooftop disconnected)	A	0.332	3,607	313,397	3.460	$12,046
		B	-	-	-	-	-
		C	-	-	-	-	-
	Infiltration Basin (Other IC disconnected)	A	0.407	4,423	387,605	4.286	$7,380
		B	-	-	-	-	-
		C	-	-	-	-	-

Land Use Group	SCM Type	HSG	Infiltration GI SCM Solution (0.4 inch) for Residential District (R25) in Tisbury				
			IC Disconnected (acres)	Storage Capacity (gallons)	Flow Volume Captured (gallons/yr)	TN Load Removed (lbs/yr)	SCM Cost ($)
Highway	Infiltration Trench (Rooftop disconnected)	A	-	-	-	-	-
		B	-	-	-	-	-
		C	-	-	-	-	-
	Infiltration Basin (Other IC disconnected)	A	-	-	-	-	-
		B	-	-	-	-	-
		C	0.012	134	8,260	0.079	$224
Open Land	Infiltration Trench (Rooftop disconnected)	A	0.226	2,455	213,318	1.776	$8,200
		B	-	-	-	-	-
		C	0.000	1	32	0.000	$2
	Infiltration Basin (Other IC disconnected)	A	3.358	36,473	3,196,145	26.644	$60,850
		B	-	-	-	-	-
		C	0.001	7	458	0.005	$12
Total	**Infiltration Trench (Rooftop disconnected)**	**A**	**16.393**	**178,059**	**15,469,584**	**169.037**	**$594,598**
		B	**-**	**-**	**-**	**-**	**-**
		C	**0.071**	**767**	**49,098**	**0.751**	**$2,562**
	Infiltration Basin (Other IC disconnected)	**A**	**36.947**	**401,305**	**35,166,217**	**361.897**	**$669,510**
		B	**-**	**-**	**-**	**-**	-
		C	**0.185**	**2,010**	**123,705**	**1.912**	**$3,354**

3.9 R50 Residential District

Figure 24 presents the HRUs for the R50 Residential District Zone. The majority of land in the district is pervious surfaces, with 11% of the area consisting of rooftops and other impervious surfaces. Figure 25 presents the GI SCM opportunities in the area. A 0.4 inch design criteria achieved a 75% reduction in flow volume and a 76% reduction in TN loading (Figure 26). The reductions were achieved at a cost of $2,816,910.

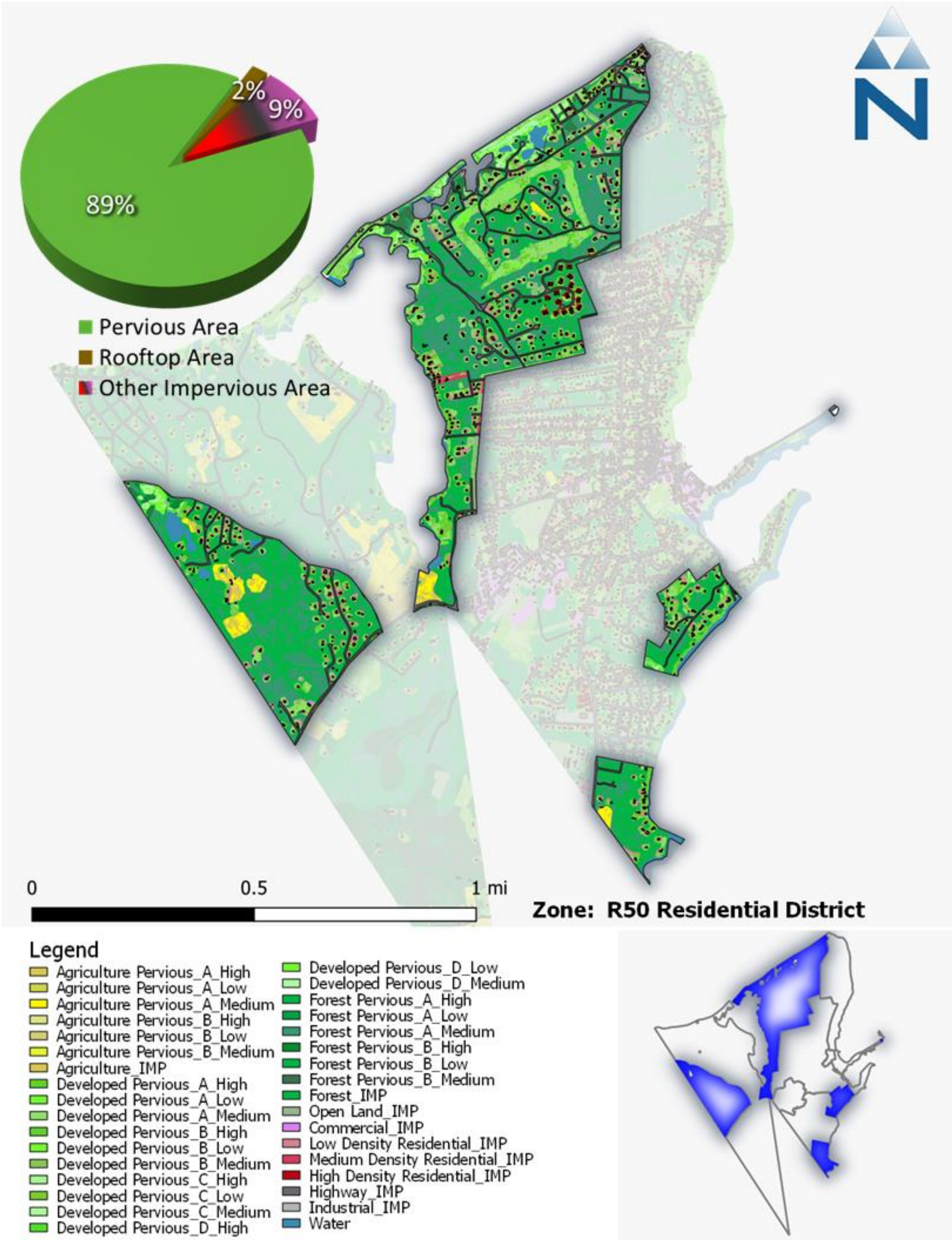

Figure 24. HRU distribution in the R50 Residential District Zone of Tisbury, MA.

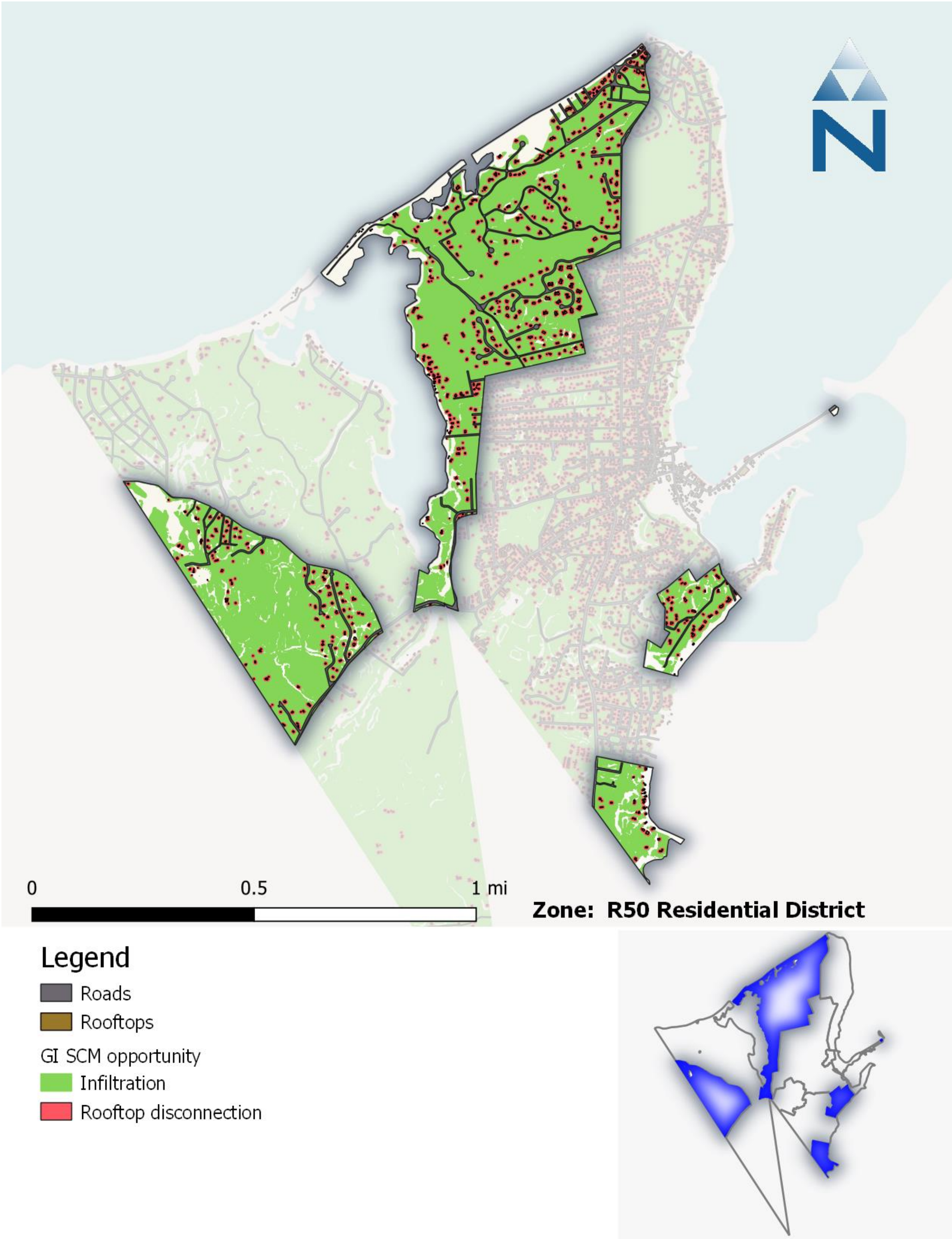

Figure 25. GI SCM opportunities in the R50 Residential District Zone of Tisbury, MA.

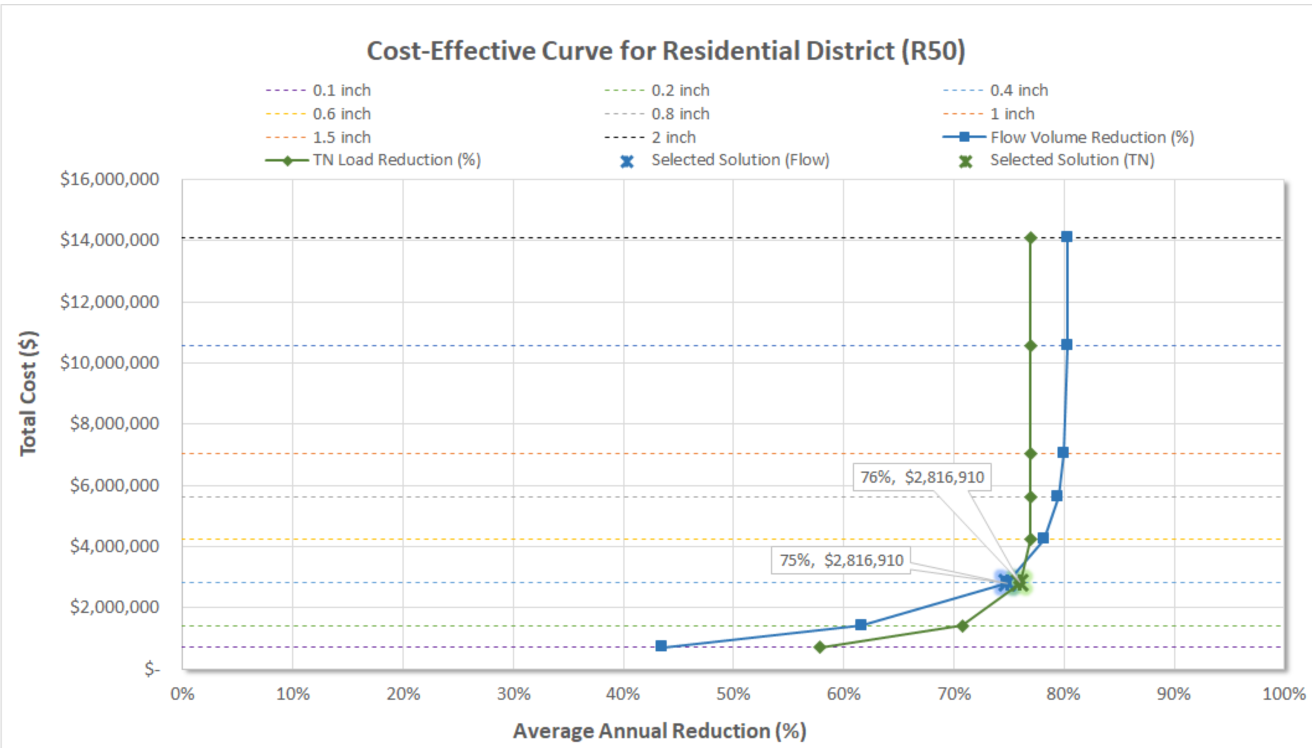

Figure 26. Cost effectiveness curves for incremental sizing of GI SCM opportunities in the R50 Residential District Zone of Tisbury, MA.

Table 17. Infiltration GI SCM Solution (0.4 inch) for the R50 Residential District of Tisbury, MA

Land Use Group	SCM Type	HSG	Infiltration GI SCM Solution (0.4 inch) for Residential District (R50) in Tisbury				
			IC Disconnected (acres)	Storage Capacity (gallons)	Flow Volume Captured (gallons/yr)	TN Load Removed (lbs/yr)	SCM Cost ($)
Forest	Infiltration Trench (Rooftop disconnected)	A	1.907	20,708	1,799,132	14.975	$69,152
		B	0.026	278	20,397	0.195	$928
		C	-	-	-	-	-
	Infiltration Basin (Other IC disconnected)	A	53.779	584,138	51,187,800	426.710	$974,536
		B	0.721	7,832	571,679	5.490	$13,066
		C	-	-	-	-	-
Agriculture	Infiltration Trench (Rooftop disconnected)	A	0.083	903	78,444	0.653	$3,016
		B	0.000	2	117	0.001	$6
		C	-	-	-	-	-
	Infiltration Basin (Other IC disconnected)	A	1.893	20,566	1,802,187	15.023	$34,310
		B	0.003	36	2,653	0.025	$60
		C	-	-	-	-	-
Commercial	Infiltration Trench (Rooftop disconnected)	A	0.390	4,231	367,558	4.411	$14,128
		B	0.002	18	1,327	0.018	$60
		C	-	-	-	-	-
	Infiltration Basin (Other IC disconnected)	A	0.848	9,210	807,042	9.699	$15,364
		B	0.004	39	2,871	0.040	$66
		C	-	-	-	-	-
Industrial	Infiltration Trench (Rooftop disconnected)	A	-	-	-	-	-
		B	-	-	-	-	-
		C	-	-	-	-	-
	Infiltration Basin (Other IC disconnected)	A	-	-	-	-	-
		B	-	-	-	-	-
		C	-	-	-	-	-
Low Density Residential	Infiltration Trench (Rooftop disconnected)	A	18.279	198,544	17,249,302	190.427	$663,006
		B	0.253	2,750	202,021	2.557	$9,184
		C	-	-	-	-	-
	Infiltration Basin (Other IC disconnected)	A	33.765	366,752	32,138,346	355.347	$611,864
		B	0.468	5,080	370,791	4.723	$8,474
		C	-	-	-	-	-
Medium Density Residential	Infiltration Trench (Rooftop disconnected)	A	0.781	8,484	737,090	8.137	$28,332
		B	-	-	-	-	-
		C	-	-	-	-	-
	Infiltration Basin (Other IC disconnected)	A	2.256	24,502	2,147,113	23.740	$40,878
		B	-	-	-	-	-
		C	-	-	-	-	-
High Density Residential	Infiltration Trench (Rooftop disconnected)	A	2.261	24,564	2,134,086	23.560	$82,028
		B	-	-	-	-	-
		C	-	-	-	-	-
	Infiltration Basin (Other IC disconnected)	A	3.598	39,084	3,424,939	37.869	$65,206
		B	-	-	-	-	-
		C	-	-	-	-	-

Land Use Group	SCM Type	HSG	Infiltration GI SCM Solution (0.4 inch) for Residential District (R50) in Tisbury				
			IC Disconnected (acres)	Storage Capacity (gallons)	Flow Volume Captured (gallons/yr)	TN Load Removed (lbs/yr)	SCM Cost ($)
Highway	Infiltration Trench (Rooftop disconnected)	A	-	-	-	-	-
		B	-	-	-	-	-
		C	-	-	-	-	-
	Infiltration Basin (Other IC disconnected)	A	-	-	-	-	-
		B	-	-	-	-	-
		C	-	-	-	-	-
Open Land	Infiltration Trench (Rooftop disconnected)	A	0.421	4,576	397,554	3.309	$15,280
		B	0.001	6	413	0.004	$18
		C	-	-	-	-	-
	Infiltration Basin (Other IC disconnected)	A	9.257	100,545	8,810,698	73.447	$167,742
		B	0.011	124	9,026	0.087	$206
		C	-	-	-	-	-
Total	**Infiltration Trench (Rooftop disconnected)**	**A**	**24.122**	**262,010**	**22,763,165**	**245.470**	**$874,940**
		B	**0.281**	**3,053**	**224,275**	**2.775**	**$10,194**
		C	**-**	**-**	**-**	**-**	**-**
	Infiltration Basin (Other IC disconnected)	**A**	**105.397**	**1,144,796**	**100,318,125**	**941.836**	**$1,909,902**
		B	**1.207**	**13,111**	**957,019**	**10.365**	**$21,874**
		C	**-**	**-**	**-**	**-**	**-**

3.10 **WC Waterfront Commercial District**

Figure 27 presents the HRUs for the Waterfront Commercial District. Over half (54%) of the land in the district consists of rooftops and other impervious surfaces. The zone has limited opportunities for GI SCM implementation (Figure 28). The majority of pervious surfaces that could represent opportunities for GI SCM installation are in in areas associated with complicating factors, these areas include close proximity to coastlines, wetlands and structures (Table 1). The analysis was based on desktop review of geospatial data, on-the-ground field assessment may help identify opportunities missed in this assessment. A 0.4 inch design criteria achieved a 63% reduction in flow volume and an 84% reduction in TN loading (Figure 29). The reductions were achieved at a cost of $619,698.

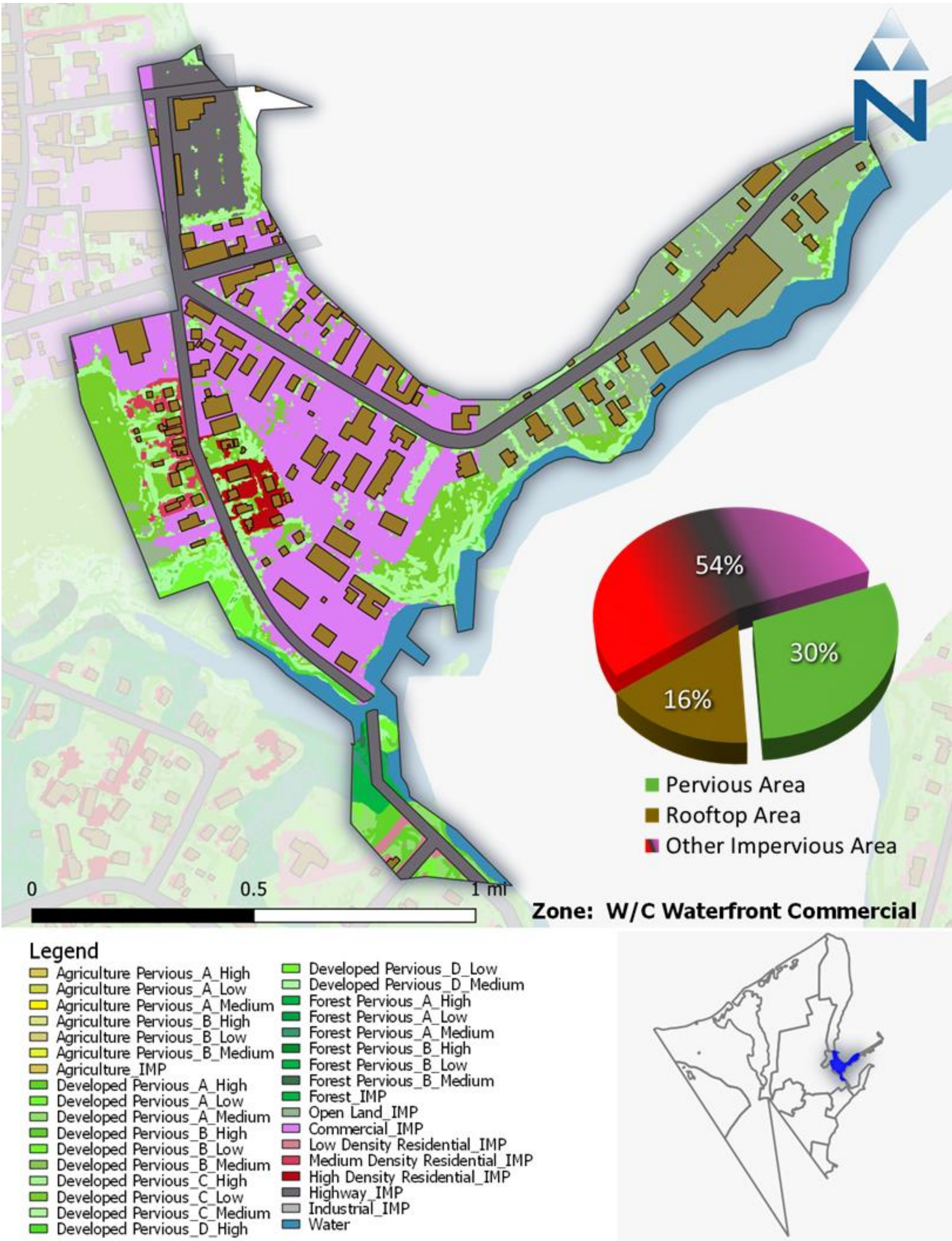

Figure 27. HRU distribution in the Waterfront Commercial Zone of Tisbury, MA.

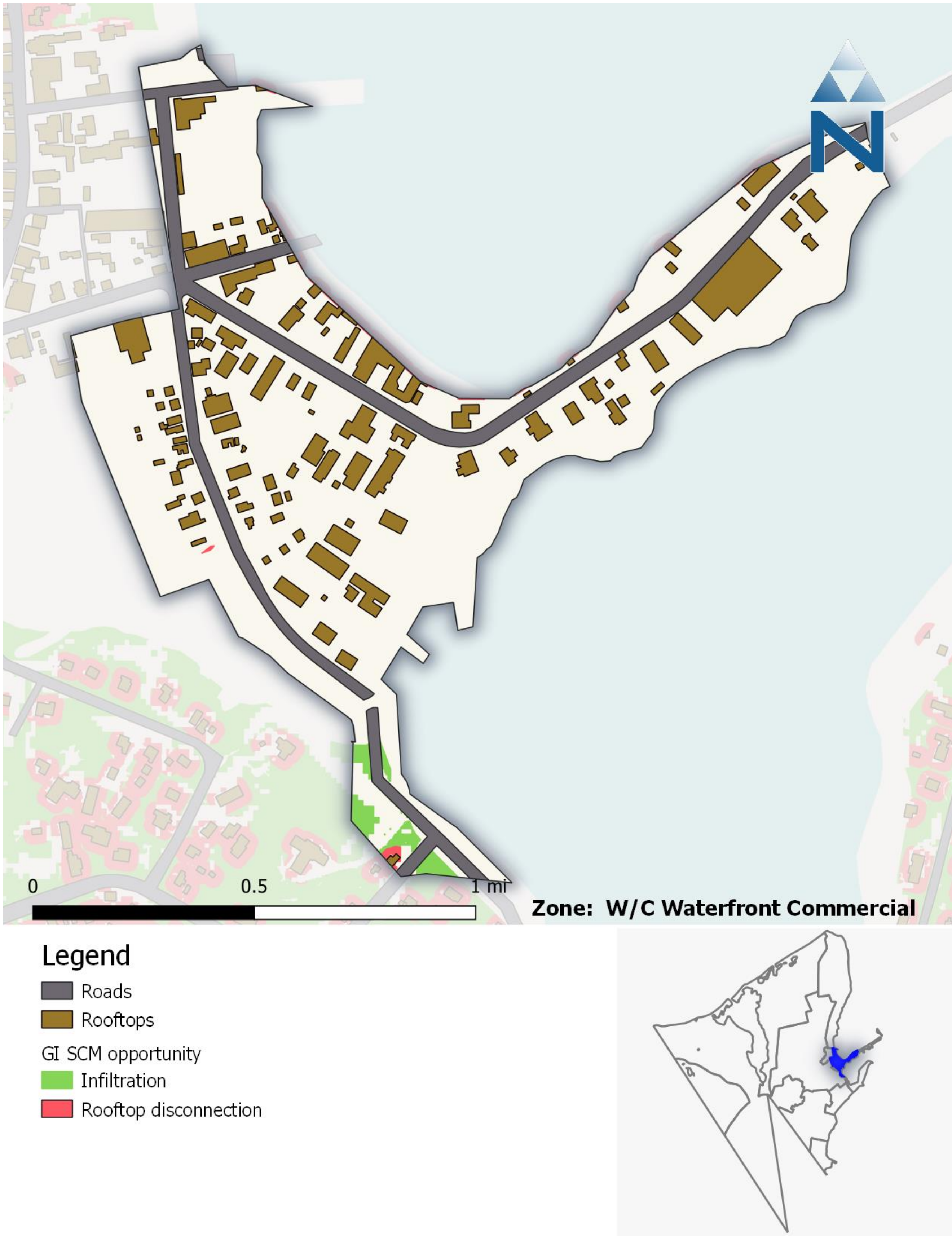

Figure 28. GI SCM opportunities in the Waterfront Commercial Zone of Tisbury, MA.

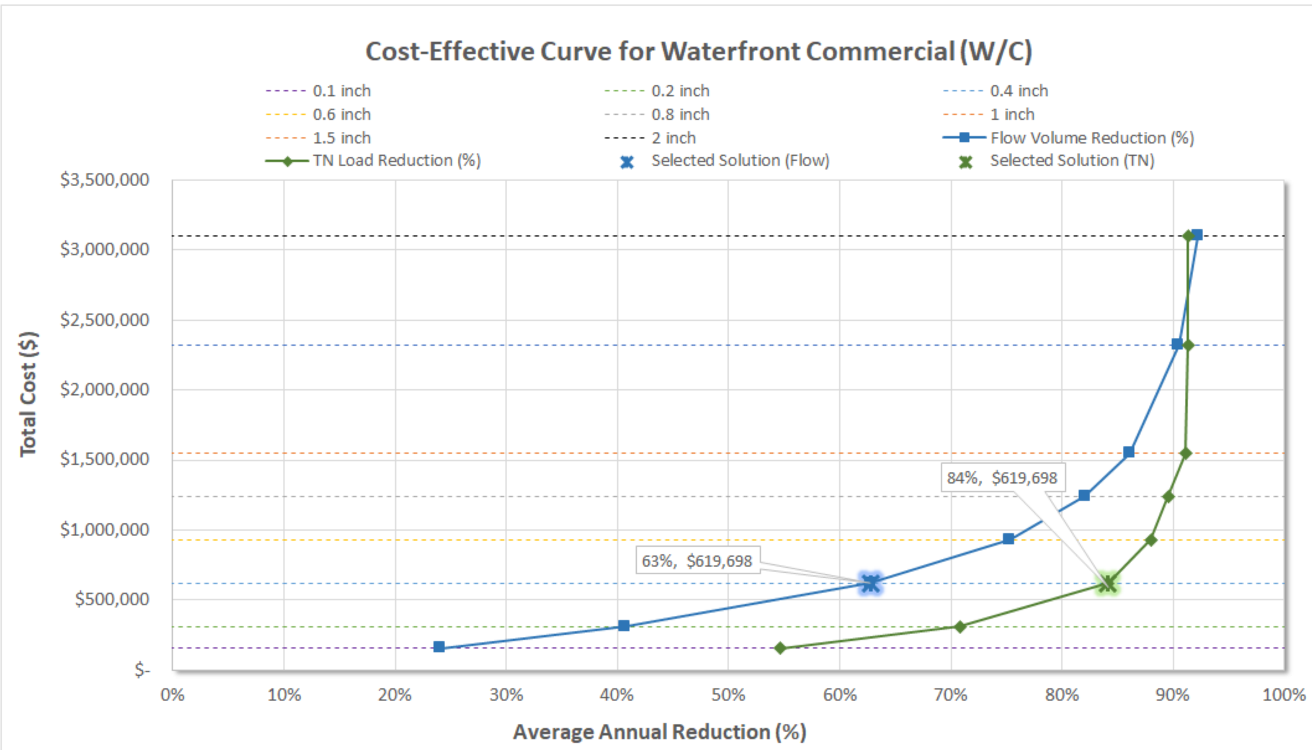

Figure 29. Cost effectiveness curves for incremental sizing of GI SCM opportunities in the Waterfront Commercial District Zone of Tisbury, MA.

Table 18. Infiltration GI SCM Solution (0.4 inch) for the Waterfront Commercial District of Tisbury, MA

Land Use Group	SCM Type	HSG	Infiltration GI SCM Solution (0.4 inch) for Waterfront Commercial (W/C) in Tisbury				
			IC Disconnected (acres)	Storage Capacity (gallons)	Flow Volume Captured (gallons/yr)	TN Load Removed (lbs/yr)	SCM Cost ($)
Forest	Infiltration Trench (Rooftop disconnected)	A	-	-	-	-	-
		B	-	-	-	-	-
		C	-	-	-	-	-
	Infiltration Basin (Other IC disconnected)	A	0.293	3,186	279,179	2.327	$5,316
		B	-	-	-	-	-
		C	-	-	-	-	-
Agriculture	Infiltration Trench (Rooftop disconnected)	A	-	-	-	-	-
		B	-	-	-	-	-
		C	-	-	-	-	-
	Infiltration Basin (Other IC disconnected)	A	-	-	-	-	-
		B	-	-	-	-	-
		C	-	-	-	-	-
Commercial	Infiltration Trench (Rooftop disconnected)	A	-	-	-	-	-
		B	-	-	-	-	-
		C	3.825	41,548	2,658,522	40.663	$138,744
	Infiltration Basin (Other IC disconnected)	A	-	-	-	-	-
		B	-	-	-	-	-
		C	11.798	128,150	7,887,252	125.421	$213,796
Industrial	Infiltration Trench (Rooftop disconnected)	A	-	-	-	-	-
		B	-	-	-	-	-
		C	-	-	-	-	-
	Infiltration Basin (Other IC disconnected)	A	-	-	-	-	-
		B	-	-	-	-	-
		C	-	-	-	-	-
Low Density Residential	Infiltration Trench (Rooftop disconnected)	A	0.017	180	15,623	0.172	$600
		B	-	-	-	-	-
		C	-	-	-	-	-
	Infiltration Basin (Other IC disconnected)	A	0.305	3,317	290,703	3.214	$5,534
		B	-	-	-	-	-
		C	-	-	-	-	-
Medium Density Residential	Infiltration Trench (Rooftop disconnected)	A	-	-	-	-	-
		B	-	-	-	-	-
		C	0.258	2,802	179,296	2.523	$9,358
	Infiltration Basin (Other IC disconnected)	A	-	-	-	-	-
		B	-	-	-	-	-
		C	0.483	5,247	322,950	4.725	$8,754
High Density Residential	Infiltration Trench (Rooftop disconnected)	A	-	-	-	-	-
		B	-	-	-	-	-
		C	0.226	2,453	156,970	2.209	$8,192
	Infiltration Basin (Other IC disconnected)	A	-	-	-	-	-
		B	-	-	-	-	-
		C	0.599	6,511	400,756	5.863	$10,864

Land Use Group	SCM Type	HSG	Infiltration GI SCM Solution (0.4 inch) for Waterfront Commercial (W/C) in Tisbury				
			IC Disconnected (acres)	Storage Capacity (gallons)	Flow Volume Captured (gallons/yr)	TN Load Removed (lbs/yr)	SCM Cost ($)
Highway	Infiltration Trench (Rooftop disconnected)	A	-	-	-	-	-
		B	-	-	-	-	-
		C	0.211	2,289	146,493	1.341	$7,646
	Infiltration Basin (Other IC disconnected)	A	-	-	-	-	-
		B	-	-	-	-	-
		C	2.159	23,447	1,443,116	13.739	$39,118
Open Land	Infiltration Trench (Rooftop disconnected)	A	0.000	5	425	0.004	$16
		B	-	-	-	-	-
		C	1.766	19,186	1,227,622	13.024	$64,068
	Infiltration Basin (Other IC disconnected)	A	0.002	16	1,441	0.012	$28
		B	-	-	-	-	-
		C	5.942	64,536	3,972,018	43.810	$107,668
Total	**Infiltration Trench (Rooftop disconnected)**	**A**	**0.017**	**185**	**16,048**	**0.176**	**$616**
		B	**-**	**-**	**-**	**-**	-
		C	**6.286**	**68,278**	**4,368,902**	**59.761**	**$228,004**
	Infiltration Basin (Other IC disconnected)	**A**	**0.600**	**6,520**	**571,324**	**5.554**	**$10,878**
		B	**-**	**-**	**-**	**-**	-
		C	**20.981**	**227,892**	**14,026,092**	**193.557**	**$380,200**

4 ABILITY OF GI SCM STRATEGIES TO ACHIEVE OBJECTIVES BEYOND WATER RESOURCES MANAGEMENT

The implementation of GI SCM strategies can be part of larger community strategies that aim to improve sustainability. Stormwater treatment can provide aesthetic, green spaces within the community (Figure 30). Investment in GI SCM is generally publicly funding from federal, state, and local sources. The planning design, construction and long-term maintenance of the GI SCM project can increase jobs and boost local economies (U.S. EPA., 2015). Tree-box filters (Figure 31) require not only engineers and contractors to design and install the system but can also support local tree nurseries.

GI SCM implementation plans should aim to safeguard, expand, and enhance a community's network of parks, recreational trails, open spaces, and working and agricultural lands. To facilitate achieving co-benefits from supporting GI SCM and urban agriculture, communities may consider listing stormwater management as a benefit or definition of urban agriculture in planning materials and zoning codes, as well as offer farmers funding and tax credits for impropriating GI SCM (American Rivers, 2015). The Commonwealth of Massachusetts has approved science-related curriculums based on the numerous processes associated with hydrology and the application of GI SCMs (MDESE, 2016). Boston has retrofitted several schools with GI SCMs that are being used as part of hands-on science studies at the schools (presentation by BWSC, 2018).

Although GI/SCM implementation consistent with this project will help to offset the impact of climate change storm events, this project did not specifically investigate climate resilience, particularly along the coastline. Consequently, given the value of waterfront property generally, next-generation ordinance/bylaws could be considered which require development/redevelopment practices to (a) eliminate/reduce IC, and (b) provide for climate resilience mitigation, including some or all of the recommendations outlined in the Tisbury Coastal Resilience Planning Report and more generally, next-generation architectural design and materials.

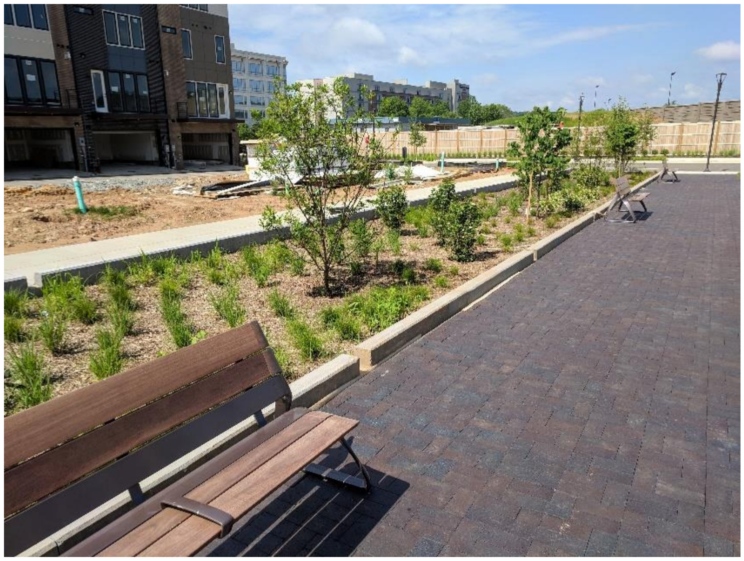

Figure 30. SCM integration into the landscape of a residential development site in Alexandria, VA.

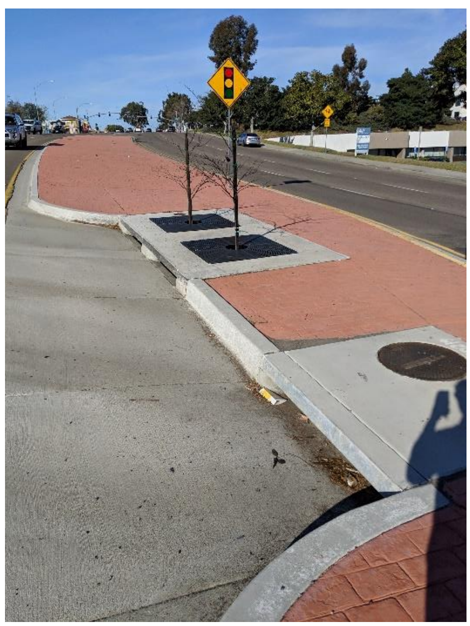

Figure 31. Treebox filter in San Diego, CA.

5 SUMMARY

The Opti-Tool was used to provide a planning level evaluation of incrementally sized GI SCM opportunities. The analysis assessed 6 types of GI SCM opportunities in Tisbury's nine development zones. Overall the analysis suggests that a 78% reduction in stormwater volume and an 81% reduction in TN can be achieved at a cost of $13.54 million. These reductions are based on treating the 0.4 inches of runoff from roofs and other impervious surfaces using infiltration-based techniques. The R3A residential district had the lowest reductions as a result of GI SCM implementation, with storm flow volume and TN loading decreasing by 57% and 54%, respectively. Alternatively, the B2 light business district had the highest reductions as a result of GI SCM implementation, with storm flow volume and TN loading decreasing by 91% and 96%, respectively. The differences in cost effectiveness are a result of the HRU composition of the zoning districts. The B2 light business district has a relatively high percentage of the total area as rooftop or other impervious surfaces, with enough opportunities for GI SCM implementation. Much the stormwater volume and TN loading were generated from impervious surfaces in this zone, and there is ample opportunity to treat the runoff. The R3A residential district was a much more rural area and implementing GI SCM to treat the relatively small (6%) of impervious area less of an impact than in more urban areas with enough opportunities.

The results of this study provide support to the implementation of a town-wide strategy to install GI and SCMs to help address flood mitigation by reducing stormwater volume and to improve water quality through TN load reductions. A successful GI SCM implementation strategy should recognize and encourage the role stormwater management can play in achieving other community objectives.

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